The Description and Use OF THE CARPENTERS-RULE:

Together with the Use of the

LINE of NUMBERS

(Inscribed thereon)

In Arithmatick and Geometry.

And the Application thereof to the Measuring of *Superficies* and *Solids* *Gaging* of Vessels, *Military Order*, Interest and Annuities: with Tables of Reduction, *&c.*

To which is added,

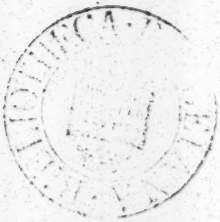
The Use of a (portable) *Geometrical Sun-dial*, with a *Nocturnal* on the backside, for the exact and ready finding the hour of the Day and Night: And other Mathematical conclusions.

Also of a UNIVERSAL DIAL for the use of *Seamen* or others.

Collected and fitted to the meanest capacity

By *J. B.*

Lond. Printed by *W. G.* for *W. Lugger*, & *W. Fisher* at the *Postern-gate* near *Tower-hill*, 1656.



To the Reader.

Courteous Reader, whomsoever thou art;

I *Shall entreat thee to take in good part this Collection of* The Uses of the Line of Numbers, *commonly called (or best known to Artificers by the name of)* Gunter's *Line*; *I write it not as a new thing, but rather as a renovation of an old one*; *and the great motive that provoked and stirred me up to it is this*, *I making and selling Rules with* Gunter's *Line on them, many a one would*

ſay to me, *How ſhall I come to know the uſe of this Line?* I reply, *that in Mr.* Gunter's *Book there the Uſe is ſet forth, but becauſe of the obſcurity of the Inſtructions there, as to the reading of the Line; and alſo the dearneſs of the Book, many a one that would gladly learn, are deterred from taking pains therein, leſt they ſhould ſpend time and oyl to no purpoſe; and alſo for want of caſes fit to their purpoſe, they are apt to think it is to no purpoſe: Therefore that I might be as an* ABCdarian *to the Inſtrumental way of working, being*

being the most proper for Mechanick men, such as Carpenters, Joyners, Masons, *and* Bricklayers, *and the like; which for the most part are ignorant of Arithmatick; and that knowledge might be encreased any way, I thought it convenient, and make no doubt of a good benefit to accrue thereby, to them whose capacities and purses in these Critical times cannot well reach to other more difficult, and dear Authors: I shall not much Apologise for my self, as to style or manner of writing (being like my self) what it is I*

beſeech you accept in as good part as it was offered, I might have implored the aid of ſome more abler Pen, but I thought Mechanick men beſt underſtand them of their own profeſſion, in this and other Diſcourſes, becauſe they are men of the ſame ſtature in knowledge and expreſſions. Poſſibly it may provoke ſome to a more accurate and univerſal Treatiſe: In the mean time take this as a Harbinger, till that come. And being apt to think that Ship-Carpenters or Seafaring men may light of it, I have added in the concluſion

(as

(as an Appendix) the Use of a perticular and Universal Sun-dial; also of a Nocturnal, or Star-dial; by which the hour of the Day and Night may be had in all places of the North latitude, from 1 degree to 66. 30 where the Day Artificial is 24 hours long: In all which I have laboured after brevity and plainness, as much as may be: And to the end you may learn to know the Stars, I have been at the charge to print a Paper with all the principal Stars in the Northern Hemisphere, from the Pole to the Equinoctial,

So that you may take any in that Compass, and they that please may do the like for the South *Hemisphere. So I wish you may reap much profit thereby, and remain willing to serve you in what I may,*

J.B.

The

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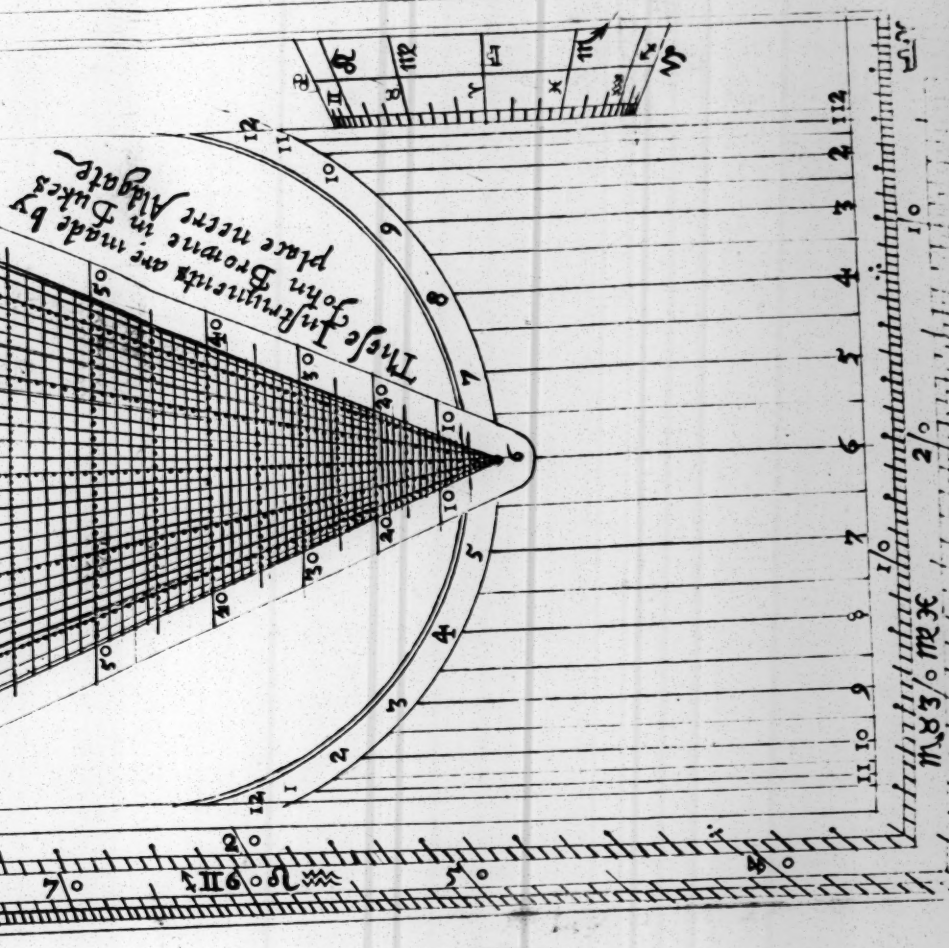
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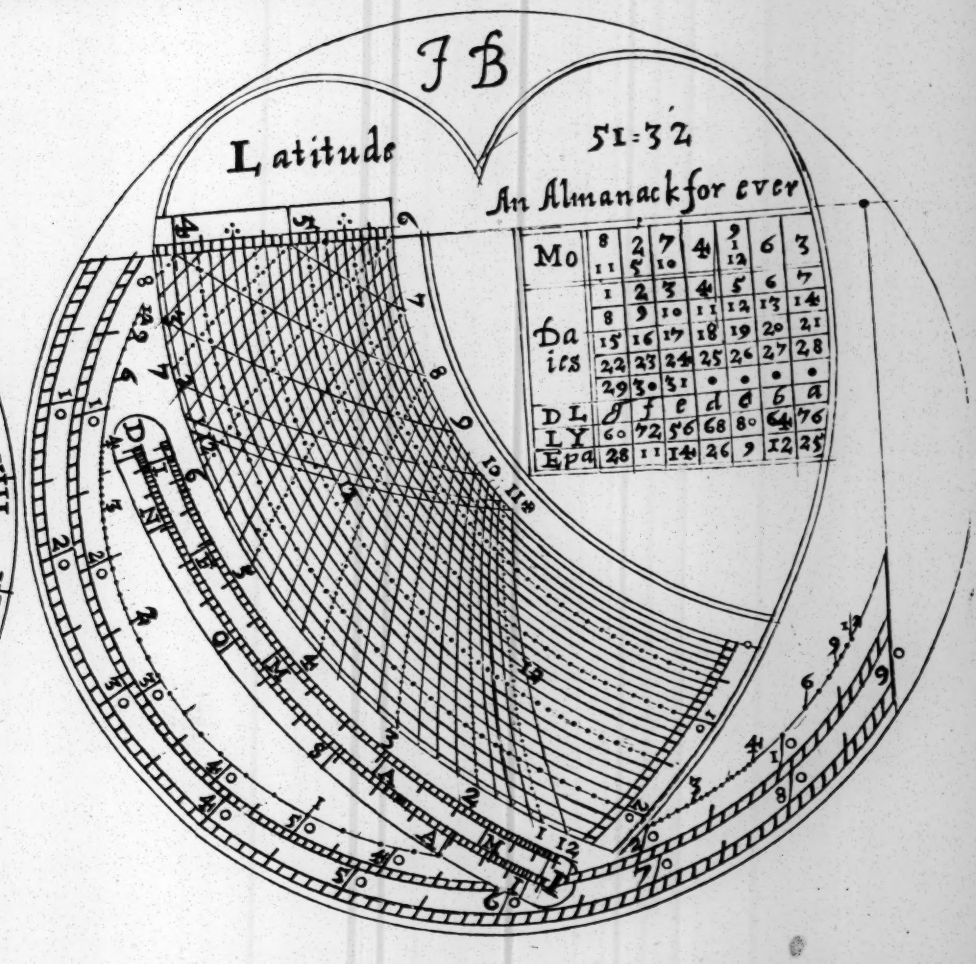
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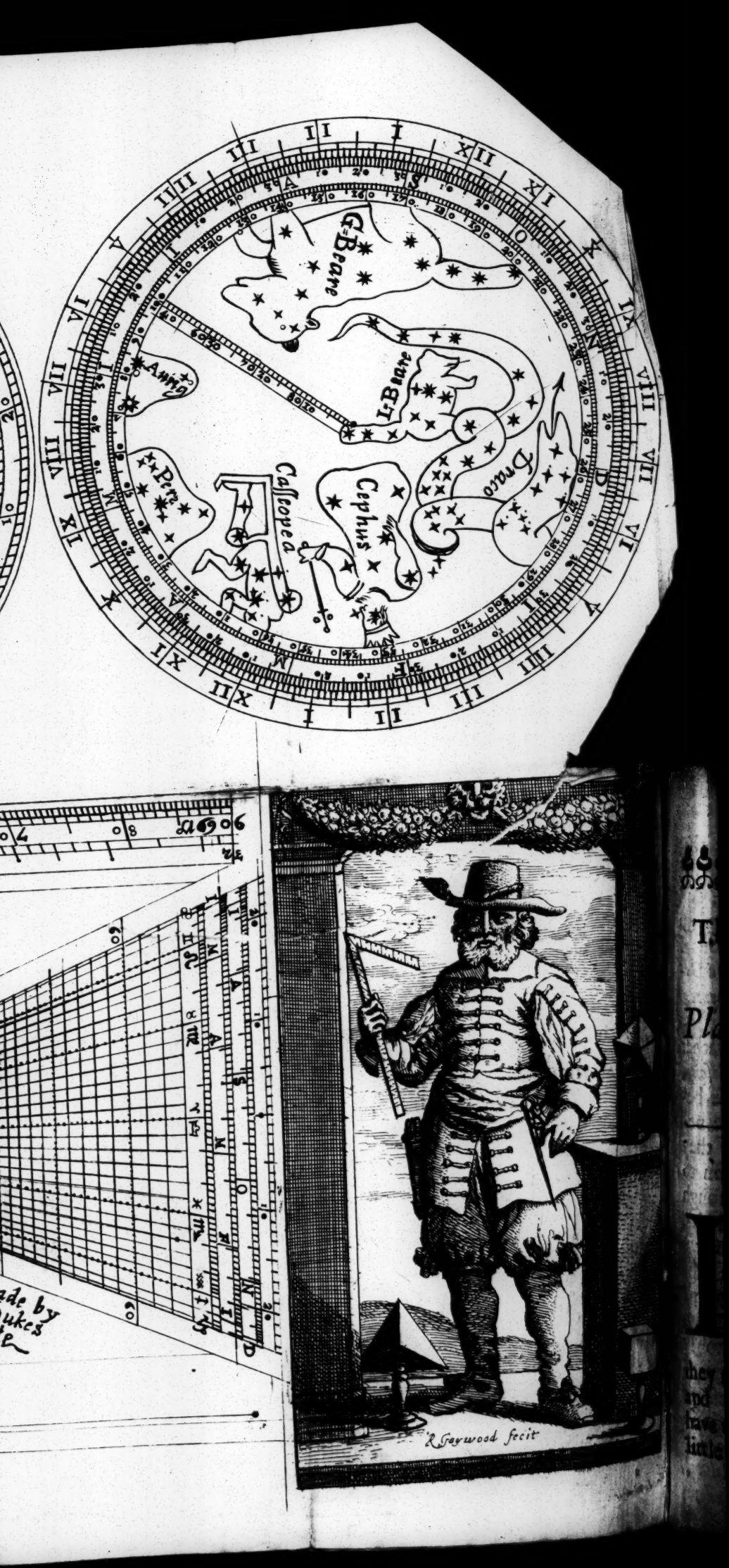
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The Description and Use OF THE *Plain Carpenters* RULE As it is now made.

CHAP. I.

I Thought good to add this Chapter for the sake of some, possibly young beginners, and them that would not be ignorant altogether in the way of Measuring therewith, though they may seldome have occasion of it; and also knowing that they that have the most knowledge, once had little enough: And farther, I find by

experience, that many there be that can measure by the plain Rule that cannot use the Line of Numbers; and som also know not the use of the plain Rule neither: For these Reasons I have added this Chapter of *The Description and use of the plain Carpenters Rule.*

It is called a *Carpenters Rule*, (rather then a *Joyners*, *Bricklayers*, *Masons*, or *Glasiers*, or the like) I suppose, because they find the most absolute necessity of it in their way, for they have as much or more occasion to use it then most other Trades, though the same Rule must measure all kind of Superficies and Solids, which two Measures measure every visible substance which is to be measured. And it is usually made of Box or Holly, 24 Inches in length, and commonly an Inch and half or an Inch and quarter in breadth; and of thickness at pleasure; and on the one side it is divided into 24 equal Inches, according to the Standard at *Guild-hall*, *London*;

London; and every one of those 24 Inches is divided into eight parts, that is, Halfes, Quarters, and Half-quarters; and the Half-Inches are known from the Quarters, and Quarters from the Half-quarters, by short, longer, and longest strokes; and at every whole Inch is set Figures, proceeding from 1 to 24, from the right hand toward the left, and these parts and figures are on both edges of one side of the Rule both ways numbred, to the intent that howsoever you hold the Rule you have the right end to measure from, provided you have the right side.

On the other side you have the lines of Timber and Board-measure. The Timber-measure is that which begins at 8 and a half, that is, when the figures of the Timber-line stand upright to you, then I say it beginns at the left end at 8 & ½, and proceeds to 36. within an Inch and ⅛ of an Inch at the end. Also at the beginning end of the Line of Timber-measure

is

is a Table of figures, which contains the quantity of the Under-measure from one Inch square to eight Inches square, for the figure 9 comes upon the Rule, as you may see neer to 8 in the Table.

On or next the other edge, and same side you have the Line of Board-measure, and when those figures stand upright, you have 6 at left or beginning end, and 36 at the other (or right) end, just 4 Inches of the end unless it be divided up to 100, then it is nigh an Inch and half of the end. This Line hath also his Table of Under-measure at the beginniug end, and begins at 1 and goes to 6, and then the divisions on the Rule do supply all the rest to 100. Thus much for Description: Now for Use.

The Inches are to measure the length or breadth of any Superficies or Sollid given, and the manner of doing it were superfluous to speak of, or once to mention, being not onely easie, but even natural to every man,

for

for holding the Rule in the left hand, and applying it to the board or any thing to be measured, you have your desire: But now for the use of the other side, I shall shew it in two or three examples in each measure that is Superficial or Sollid. And first in Superficial or Board-measure.

Example the first.

The breadth of any Superficies (as Board, or Glass, or the like) being given, to find how much in length makes a Square Foot, (or is equal to 12 Inches broad, and 12 Inches long; for so much is a true Foot Superficial.)

To do this, look for the number of Inches your Superficies is broad in the Line of Board-measure, and keep your finger there, and right against it on the Inches side you have the number of Inches that goes to make up a Foot of Board or Glass, or any Superficies. Suppose I have a piece 8 Inches broad, How many Inches makes a Foot? I look for 8 on the Board-measure,

measure, and just against my finger (being set to 8) on the Inch-side, I find 18, and so many Inches long at that breadth goes to make a Foot Superficial.

Again, suppose it had been 18 Inches broad, then I find 8 Inches in length, to make a Foot superficial; but if 36 Inches broad, then 4 Inches in length makes a Foot.

Or you may do it more easier thus: Take your Rule & hold it in your left hand, and apply it to the breadth of your Board or Glass, making the end that is next 36 even with one edge of the Board or Glass, and the other edge of the Board sheweth how many Inches or Quarters of an Inch goes to make a Foot of the Board or Glass. This is but the converse of the former and needs no example, for laying the Rule to it, and looking on the Board-measure you have your desire.

Example

Example the ſecond.

A Superficies of any length and breadth to find the Content, that is, how many Foot there is in it.

Having found the breadth, and how much makes one Foot, turn that over as many times as you can, for ſo many Foot is there in that Superficies: But if it be a great breadth, then you may turn it over two or three times, and then take that together, and ſo ſay 2, 4, 6, 8, 10, *&c.* or 3, 6, 9, 12, 15, 18, 21, and till you come to the end of the Superficies. Note that the three ſhort ſtrokes between figure and figure, are the Quarters; as thus, 8 and a quarter, 8 and a half, 8 and three quarters, then 9, *&c.* till you come to 30, and then 30 and a half, 31, *&c.* to 36. And if it be divided any further, it is to whole Inches onely to 100.

The Use of the Table at the beginning end of the Board-measure.

First you have five ranks of figures, the first or uppermost is the number of Inches that any Superficies is broad, and the other 4 are Feet, and Inches, and parts of an Inch that goes to make up a Foot of Superficial measure: As for example, at 5 Inches broad you must have 2 Foot, 4 Inches, and 4 Fifths of an Inch more, that is, 4 parts of 5, the Inch being divided into 5 parts; but where you have but two figures beside the uppermost, and Ciphers in the rest, you must read it thus, At two Inches broad you must have six Foot in length, no Inches no parts.

Thus much for the Use of the Line of Superficial or Board-measure.

The

The Uſe of the Line of (Sollid) or Timber-meaſure.

The uſe of this Line is much like the former: For firſt you muſt learn how much your piece is ſquare, and then look for the ſame number on the Line of Timber-meaſure, and the ſpace from thence to the end of the Rule is the true length at that ſquareneſs, to make a Foot of Timber.

Example.

I have a piece that is 9 Inches ſquare, I look for 9 on the Line of Timber-meaſure, and then I ſay the ſpace from 9 to the end of the Rule is the true length to make a Foot of Timber, and it is neer 21 Inches, eights of an Inch.

Again, ſuppoſe it were 24 Inches ſquare, then I find 3 Inches in length makes a Foot, for ſo I find 3 Inches on the other ſide, juſt againſt 24: But if it were ſmall Timber, as under 9 Inches

Inches ſquare, then you muſt ſeek the ſquare in the upper rank in the Table, and right under you have the Feet Inches, and parts that goes to make a Foot ſquare, as was in the Table of Board-meaſure. As ſuppoſe 7 Inches ſquare, I find in the Table 2 Foot 11 Inches and 2 ſevenths of an Inch, divided into 7 parts, at 8 you find onely 2 Foot, 3 Inches -- 0 parts, and ſo for the reſt.

But if a piece be not juſt ſquare but broader at one ſide then the other, then the uſual way is to add them both together, and to take half for the ſquare; but if they differ much then this way will be very erroneous, and therefore I refer you to the following Rules: But if it be round Timber, then take a ſtring and girt it about, and the fourth part of this is uſually allowed for the ſide of the ſquare, and then you deal with it as if it were juſt ſquare.

Thus much for the Uſe of the Plain Carpenters Rule.

I have also added a Table for the Under-measure for Timber and Board to Inches and Quarters; and the use is thus: Look on the left side for the number of Inches and Quarters your Timber is square, or your Board is broad, and right against it you have the Feet, Inches, tenth part of an Inch, and tenth of a tenth (or hundredth part of an Inch) that goeth to make a Foot of Timber or Board.

Example.

A piece of Timber 3 Inches 1 quarter square will have 13 7 5 9 parts to make a Foot. And a Board 3 Inches and a quarter broad must have 3 8 3 0 in length to make a Foot, and so of the rest, as is plain by the Table, and needs no further explication, being common to most Artificers.

F. Inch. 10. 100.

F. Inch. 10. 100.

The

A Table for the Vnder Timber-measure to Inches & Quarters:						A Table for the Vnder-Board-m: to Inch: & Qu:				
Inc	quar.	feet	in h.	10	100		feet	in	10.	100
	1	2303	11	9	9	.	48	0	0	0
	2	576	0	0	0	.	24	0	0	0
	3	256	0	0	0	.	16	0	0	0
1	1	144	0	0	0	1	12	0	0	0
	1	92	1	9	7		9	7	2	0
	2	64	0	0	0		8	0	0	0
	3	47	0	2	4		6	10	2	9
2	2	36	0	0	0	2	6	0	0	0
	1	28	4	3	3		5	4	0	0
	2	23	0	4	1		4	9	6	0
	3	19	0	4	1		4	4	3	6
3	3	16	0	0	0	3	4	0	0	0
	1	13	7	5	9		3	8	3	0
	2	11	9	0	6		3	5	1	4
	3	10	1	8	8		3	9	4	0
4	4	9	0	0	0	4	3	2	0	0
	1	7	11	6	6		2	9	8	8
	2	7	1	3	3		2	8	0	0
	3	6	4	5	9		2	6	3	1
5	5	5	5	1	2	5	2	4	8	0
	1	5	2	6	9		2	3	4	2
	2	4	9	1	2		2	2	1	8
	3	4	4	2	6		2	1	0	4
6	6	4	0	0	0	6	2	0	0	0
	1	3	4	2	3		1	11	0	5
	2	3	4	9	0		1	10	1	5
	3	3	1	9	3		1	9	3	3
7	7	2	11	2	8	7	1	8	5	8
	1	2	8	8	6		1	7	8	6
	2	2	6	7	2		1	7	2	0
	3	2	4	7	7		1	6	5	8
8	8	2	3	0	0	8	1	6	0	0
	1	1	11	9	2		1	5	4	5

The Description and Use OF THE LINE of NUMBERS,

(*commonly called* Gunter's *Line*)

In Arithmatick, and Geometry, and Gaging of Vessels, *&c.*

The definition and description of the Line of Numbers, and Numeration thereon.

The Line of Numbers is only the Logarithmes contrived on a Ruler, and the several ranks of figures in the Logarithmes are here expresst by short, and longer, and longest divisions,

sions; and they are so contrived in proportion one to another, that as the Logarithmes by adding together, and subtracting one from another produce the *quesita*, so here, by turning a pair of Compasses forward or backward, according to due order, from one point to another, doth also bring out the *quesita* in like manner.

For the length of this Line of Numbers, know, that the longer it is the better it is, and for that purpose it hath been contrived several wayes, as first, into a Rule of two Foot long, and three Foot long by Mr. *Gunter*, and I suppose it was therefore called *Gunters Line*. Then that Line doubled or laid so together, that you might work either right on, or cross from one to another, by Mr. *Windgate*, afterwards projected in a Circle, by Mr. *Oughtred*, and also to slide one by another, by the same Author; and last of all projected (and that best of all hithe to, for largeness, and consequently for exactness) into a Serpentine,

genine, or winding circular Line, of 5, or 10, or 20 turns, or more or less, by Mr. *Brown*; the uses being in all of them in a manner the same, onely some with Compasses, as Mr. *Gunter*'s and Mr. *Windgate*'s; and some with flat Compasses, or an opening Index, as Mr. *Oughtred*'s and Mr. *Browne*'s, and one without either as the sliding Rules; but the Rules or precepts that serves for the use of one, will indifferently serve for any; But the proportion that I shall cheifly confine my self to, is that of Mr. *Gunters*; being the most proper for to be inscribed on a Carpenters Rule, for whose sakes I undertake this collection of the most useful, convenient, and proper applications to their uses in Arithmatique and Geometry. Thus much for definition of what manner of Lines of Numbers there be, and of what I intend cheifly to handle in this place.

The order of the divisions on this line of numbers, and commonly on most other, is thus, it begins with 1, and

1, and so proceeds with 2, 3, 4, 5, 6, 7, 8, 9; and then 1, 2, 3, 4, 5, 6, 7, 8, 9, 10; whose proper power or order of numeration is thus: The first 1 doth signifie one tenth of any whole number or integer; as one tenth of a Foot, Yard, Ell, Perch, or the like; or the tenth of a penny, shilling, pound, or the like, either in weight, or number, or measure; and so consequently, 2 is 2 tenths; 3, three tenths; and all the small intermediate divisions, are a 100. parts of an integer, or a tenth, of one of the former tenths; so that 1 in the middle, is one whole integer, and 2 onwards two integers, 10 at the end is 10 integers: Thus the line is in its most proper acception or natural division.

But if you are to deal with a greater number then 10 then 1 at the begining must signifie 1 integer, and 1 in the middle 10 integers, and 10 at the end 100 integers. But if you would have it to a figure more, then the

the first 1 is ten, the second a hundred, the last 10 a thousand. If you proceed further, then the first 1 is a 100. the middle 1 a 1000. and the 10. at the end is 10000. which is as great a number as you can well discover, on this or most ordinary lines of numbers: and so far with convenient care, you may resolve a question very exactly. Now any number being given under 10000. to finde the point representing it on the rule, do thus.

Numeration on the Line of numbers.

Problem 1.

Any whole number being given under four figures, to finde the point on the line of numbers that doth represent the same.

First, Look for the first figure of our number, among the long divisions, with figures at them, and that

leads you to the first figure of your number: then for the second figure, count so many tenths from that long division onwards, as that second figure amounteth to; then for the third figure, count from the last tenth, so many centesmes as the third figure contains; and so for the fourth figure, count from the last centesme, so many millions, as that fourth figure hath unites, or is in value, and that shall be the point where the number propounded is on the line of numbers: take two or three examples.

First, I would finde the point upon the line of numbers representing 12. now the first figure of this number is one, therefore I take the middle one for the first figure; then the next figure being 2. I count two tenths from that 1. and that shall be the point representing 12. where usually there is a brasse pin with a point in it.

Secondly, To finde the point representing 144. First, as before I ta-

for 1. the first Figure of the number 144. the middle Figure 1. then for the second Figure *(viz.* 4.) I count 4. tenths onwards for that: Lastly, for the other 4. I count 4. centesmes further, and that is the point for 144.

Thirdly, To finde the point representing 1728.

First, As before, for 1000. I take the middle 1. on the line.

Secondly, For 7. I reckon seven tenths onward, and that is 700.

Thirdly, For 2. reckon two centesmes from that 7th. tenth for 20.

And lastly, For 8. you must reasonably estimate that following centesme, to be divided into 10. parts (if it be not expres'd, which in lines of ordinary length cannot be done) and 8. of that supposed 10. is the precise point for 1728. the number propounded to be found, and the like of any number whatsoever.

But if you were to finde a fraction, or broken number, then you must consider, that properly, or absolutely,

the line doth expreſſe none but decimall fractions: as thus, $\frac{1}{10}$ or $\frac{1}{100}$ or $\frac{1}{1000}$ and more neerer the rule in common acception cannot expreſſe; as one inch, and one tenth, or one hundredth, or one thouſandth part of an inch, foot, yard, perch, or the like, in weight, number, or time, it being capable to be applyed to any thing in a decimal way: but if you would uſe other fractions as quarters, half quarters, ſixteens, twelves, or the like, you may reaſonably read them, or elſe reduce them from decimalls, to thoſe fractions, of which more in the following Chapters; for more plainneſs ſake, take two or three obſervations:

1. That you may call the 1. at the beginning, either one thouſand, one hundred, or one tenth, or one abſolutely, that is, one integer, or whole number, or ten integers, or a hundred, or a thouſand integers, and the like may you cal 1. in the middle, or 10. at the end. 2. That whatſoever value or denomination you put on 1, the ſame value

value or denomination all the other figures must have successively, either increasing forward, or decreasing backwards; and their intermediate divisions accordingly, as for example;

If I call 1 at the beginning of the line, one tenth of any integer, then 2 following must be two tenths, 3. three tenths, *&c.* and 1 in the middle 1 integer, 2 two integers, and 10 at the end must be ten integers.

But if one at the beginning be one integer, then 1 in the middle must be 10 integers, and 10 at the end 100 integers, and all the intermediate figures 20, 30, 40, 50, 60, 70, 80, 90. integers, and every longest division between the figures, 21, 22, 23, 24, 25, 26, *&c.* integers, and the shortest divisions tenths of those integers, and so in proportion infinitely: as [1 ° 1.10] [1.10. 100.] [10.100. 1000.] [100. 1000. 10000.] in all which 4 examples, the first order of Figures, *viz.* $\frac{1}{10}$ 1. 10.100. represents the first 1. on the line of numbers: the second

order of Figures, *viz.* 1.10.100.1000. is repreſented by the middle 1 on the line of numbers: the laſt order or place of Figures, *viz.* 10. 100. 1000. 10000. is repreſented by the 10. at the end of the line of numbers.

3. That I may be plain (yet further) if a number be propounded of 4 Figures, having two cyphers in the middle, as 1005. it is expreſſed on the line, between that prime to which it doth belong, and the next centeſme or ſmall diviſion next to it; but if you were to take 5005 where there are not ſo many diviſions, you muſt imagine them ſo to be, and reaſonably eſtimate them accordingly. Thus much for numeration on the line, or naming any point found on the Rule, in its proper value and ſignification.

CHAP.

Chap. II.

Probleme 1.

Two numbers being given, to finde a third Geometrically proportional unto them, and to three a fourth, and to four a fifth, &c.

Geometrical proportion is, when divers numbers being compared together, differ among themselves, increasing or decreasing, after the rate or reason of these numbers, 2.4.8.16. 32. for as 2 is half 4. so is 8 half 16. and as this is continued, so it may be also discontinued, as 3. 6. 14. 28; for though 3 is half 6, and 14 half 28. yet 6 is not half 14, nor in proportion to it, as 3 is to 6: there is also arithmetical, and musical proportion; but of that in other more large discourses, being not material to our present purpose (though I may hint it afterward.)

To finde this by the numbers, extend the Compaſſes upon the line of numbers, from one number to another, this done, if you apply that extent (upwards or downwards, as you would either increaſe or diminiſh,) from either of the numbers propounded, the moveable point will ſtay on the 3 proportional number required. Alſo the ſame extent applyed the ſame way from the third, will give you a fourth, and from the fourth a fifth, *&c.*

Example.

Let theſe two numbers 2 and 4 be propounded to finde a third proportion to them. (that is, to finde a number that ſhall beare the ſame proportion to 4, that 2 doth beare to 4.) and then to that 3d, a fourth, fifth, & ſixth, *&c.*) Extend the Compaſſes upon the firſt part of the line of numbers, from 2 to 4 this done, if you apply the ſame extent upwards from 4, the moveable point

point will fall upon 8, the third proportional required, and then from 8. it will reach to 16. the fourth proportional, and from 16 to 32 the fifth, and from 32 to 64 the sixth proportional; but if you will continue the progression further, then remove the Compasses to 64 in the former part of the line, and the moveable point will stay upon 128 the seventh proportional, and from 128 to 256 the eighth, and from 256 to 512 the ninth, *&c.* contrarily to this, if you would diminish as from 4 to 2 extend the Compasses from 4 to 2, and the moveable point will fall on 1, and from 1 to $\frac{5}{10}$ or 5 of ten, which is one half (by the second Problem of the first Chapter) and from 5. to 25. or $\frac{2}{5}$ and so forward.

But generally in this and most other work make use of the small divisions in the middle of the line, that you may the better estimate the fractions of the numbers you make use on; for observe, look how much you

misse in setting the Compasses to the first and second terme, so much or more will you erre in the fourth: therefore the middle part will be most useful; as for example, as 8 to 11, so is 12, to 16. 50. or 5. if you do imagine one integer to be divided but into 10 parts, as they are on the line, on a twofoot Rule; but on the other end you cannot so well express a small fraction as there you may.

PROB. 2.

One number being given to be multiplyed by a nother number given, to finde the product.

Extend the Compasses from 1 to the multiplicator, and the same extent applyed the same way from the multiplicand, will cause the moveable point to fall on the product.

Example,

Example.

Let 6 be given to be multiplyed by 5, here if you extend the Compasses from 1 to 5, the same extent will reach from 6 to 30. which number 30 though it be numbred but with 3, yet your reason may regulate you, to call it 30. and not 3: for look what proportion the first number beares to 1, the same must the other number (or multiplicand) beare to the product, which in this place cannot be 3 but 30.

Another Example for more plainnes.

Let 125 be given to be multiplyed by 144, extend the Compasses from 1 to 125, and the moveable point will fall on 18000 now to read this number 18000 (so much and no more) you must consider that as in 125 there is two figures more than in 1. so there must be 2 figures more in the product than in the multiplicand; and as for the

the order of reading the numbers, you may consider well the first Problem of the first Chapter: some other examples for more light.

3. As 1. to 25. so 30 to 750. as 1. to 8, so 6 to 48. as 1 to 9, so 9 to 81. as 1 to 12, so 20 to 240. One help more I shall adde as to the right computation of the last figure in 4 figures (for more cannot be well expreſt, (on ordinary lines, as that on a twofoot Rule is) therefore if you are to multiply two figures, by two figures, usually the product comes out in four figures: now for right naming the last figure, write them down: as thus, 75 by 63. now you multiply 5 by 3. that is 15. for which you by vulgar Arithmetick, set down 5. and carry 1. therefore 5 is the last figure in the product, and it is 4725.

PROBLEM

PROBLEM 3. Of Diviſion.

One number being given to be divided by another, to finde the quotient.

Extend the Compaſſes from the diviſor to 1, and the ſame extent will reach from the dividend, to the quotient, as for example;

Let 750 be a number given to be divided by 25 (the diviſor) I extend the Compaſſes downward, from 25 to 1, then applying of that extent the ſame way from 150, the other point of the Compaſſes will fall upon 30, the quotient ſought, or you may ſay, as 25 is to 750, ſo is 1 to 30.

2. Let 1728 be given to be divided by 12, ſay as 12 is to 1, ſo is 1728 to 144. extend the Compaſſes from 12 to 1, and the ſame extent ſhall reach the ſame way from 1728 to 144. or as before, as 12 to 1728. ſo 1 to 144.

3. If the number be a decimall fraction, then you work as if it were an

an absolute whole number; but if it be a whole number, joyned to a decimall fraction, it is wrought here as properly as a whole number; example, I would divide 111.4 by 1.728. extend the Compasses from 1.728. to 1, the same extent applyed from 111.4. shall reach to 64.5. so again 56.4. being to be divided by 8.75. the quotient will be found to be 6.45.

Now to know of how many Figures any quotient ought to consist, it is necessary to write the *dividend* down, and the divisor under it, and see how often it may be written under it; for so many figures must there be in the quotient, as in multiplying this number 12231, by 27. according to the rules of division. 27. may be written 3 times under the dividend: therefore there must be 3 Figures in the quotient; for if you extend the Compasses from 27 to 1, it will reach from 12231, to 453. the quotient sought for.

Note, That in this, and also in all other

other questions, it is best to order it so, as that the Compasses may be at the closest extent; for you may take a close extent more easily and exactly, than you can a large extent, as by experience you will finde.

PROB. 4.

To three numbers given to finde a fourth in a direct proportion, (or the rule of 3. *direct.)*

Extend the Compasses from the first number to the second; that done, the same extent applyed the same way from the third, will reach to the fourth proportional number required.

Example.

If the circumference of a Circle, whose diameter is 7, be 22, what circumference shall a Circle have, whose diameter is 14? Extend the Compasses upward from 7. in the first part,

to

to 14 in the second, and that extent applyed the same way, shall reach from 22 to 44. the fourth proportional required; for so much shall the circumference of a Circle be, whose diameter is 14.—and the contrary if the circumference were given.

Again, A second Example, if 8. foot of Timber be worth 10 shillings, how much is 12 foot worth? extend the Compasses from 8 to 10, (either in the first part or second) the same extent applyed the same way from 12, shall reach to 15. which is the answer to the question; for so many shillings is 12 foot worth.

PROB. 5.

Three numbers being given to finde a fourth in an inversed proportion, (or the back Rule of 3.)

Extend the compasses from the first of the numbers given, to the second of the same denomination, if that distance

ſtance be applyed from the third number backwards, it ſhall reach to the fourth number ſought.

If 60 pence be 5 ſhillings, how much is 30 pence? *facit* 2.5. two ſhillings, five tenths of a ſhilling, that is, being reduced, 2 ſhillings 6 pence.

Again, If 60 men can raiſe a Breſtwork of a certain length and breadth in 48 houres, how long will it be ere 40 men can raiſe ſuch another?— Extend the Compaſſes from 60. to 40. numbers of like denomination, *viz.* of Men; this done that extent applyed the ſame way from 48. will reach to 72, the fourth number you look for. Therefore I conclude, that 40 men will perform as much in 72 houres, as 60 men will do in 48 houres.

Four Questions and their Answers, to shew the various forms of working on the line of numbers.

1. If 12 men raise a frame in ten dayes, in how many dayes might 8. men raise the like frame? Reason tells me, that fewer men must needs have longer time; therefore the work is thus, as 12 is to 8, so is 10, to 15, by the last Rule.

2. If 60 yards of stuffe, at 3 quarters of a yard broad, would hang about a certain room; how many yards of stuffe of half a yard broad, will serve to hang about the same room? the work is thus, as 5 10th to 7 10th $\frac{1}{2}$, so is 60, to 90.

3. If to make a foot superficial, 12 inches in breadth, do require 12 inches in length, the breadth being 16 inches, how many inches in length must I have to make a foot superficial? the work is thus, as 16, is to 12, so is 12 to 9, the number of inches to make a foot.

4. If

4. If to make a foot solid, a base of 144 inches require 12 inches in height, a base being given of 216 inches, how much in height makes a foot solid? the work then is, as 216 is to 144, so is 12 to 8. or otherwise thus, as 12 is to 216, so is 144 to 8. the height sought.

PROB. 6.

To three numbers given to finde a fourth in a doubled proportion.

This Problem concerns questions of proportions between lines and superficies: now if the denomination of the first and second termes be of lines, then extend the Compasses from the first terme to the second, (of the same kind or denomination,) this done, that extent applyed twice, the same way from the third terme, the moveable point will stay upon the fourth terme required.

Example,

Example.

If the content of a Circle, whose Diameter is 14, be 154, what will the content of a Circle be, whose Diameter is 28?

Here 14 and 28 having the same denomination, *viz.* of lines, I extend the Compasses from 14 to 28, then applying that extent the same way, from 154 twice, the moveable point will fall on 616 the fourth proportional sought, that is, first from 154 to 308, and from 308 to 616.

But if the first denomination be of superficial content, then extend the Compasses unto the half of the distance, between the first and second of the same denomination; so the same extent will reach from the third to the fourth Example.

If the content of a Circle being 154 have a Diameter, that is 14 what shall the Diameter of a Circle be, whose content is 616? Divide the distance betwixt 154 & 616 into 2 equal parts,

parts, then set one foot in 14, the other shall reach to 28, the Diameter required.

The like is for squares; for if a square whose side is 40 foot, contain 1600 foot: how much shall a square contain, whose side is 60 foot? take the distance from 40 to 60, and apply it twice from 1600, and the moveable point will stay on 3600, the content sought for.

PROB. 7.

To three numbers given to finde a fourth in a triplicated proportion.

The use of this *Problem*, consisteth in questions of proportion, between lines and solids, wherein if the first and second termes have denomination of lines, then extend the Compasses from the first to the second, that extent applyed three times from the third, will cause the moveable point to stay on the fourth proportional required.

Example,

Example.

If an Iron Bullet, whoſe Diameter is 4 inches, ſhall weigh 9 pounds, what ſhal another Iron Bullet weigh, whoſe Diameter is 8 inches? Extend the Compaſſes from 4 to 8, that extent applyed the ſame way 3 times from 9, the moveable point will fall at laſt on 72, the fourth proportional and weight required, that is, in ſhort thus, as 4 to 8, ſo 9 to 18, ſo 18 to 36, ſo 36 to 72.

But if the two given termes be weight, or contents of ſolids, and (the Diameter or ſide of a ſquare, or) a line is ſought for, then divide the ſpace between the two given termes of the ſame denomination into three parts, and that diſtance ſhall reach from the third to the fourth proportional.

Example,

Example.

Divide the ſpace between 9 and 72 in three parts, that third part ſhall reach from 8 to 4 (or from 4 to 8, as the queſtion was propounded, either augmenting or diminiſhing.)

Alſo if a cube, whoſe ſide is 6 inches contain 216 inches, how many inches ſhall a cube contain, whoſe ſide is 12 inches? Extend the Compaſſes from 6 to 12, that extent meaſured from 216 in the firſt part of the line of numbers three times, ſhall at laſt fall upon 1728, in the ſecond part of the line of numbers; for note, if you had begun on the ſecond part, you would at three times turning, have fallen beyond the end of the line; and the contrary as above, holds here in ſquares alſo.

PROB. 8.

Betwixt two numbers given to finde a mean arithmetically proportional.

This may be done without the help of the line of numbers: nevertheleſs, becauſe

becauſe it ſerves to finde the next following, I ſhall here inſert it, though I thought to paſſe both this and the next over in ſilence, yet to ſet forth the excellency of number, I have ſet them down; and the Rule is this, *Add half the difference of the given termes to the leſſer of them, and that aggregate (or ſum) is the Arithmetical mean required.*

Example.

Let 10 and 40 be the termes given, now if you ſubtract one out of the other, their difference is 30, whoſe half difference 15, added to 10, the leſſer terme makes 25, and that is the Arithmetical mean ſought.

PROB. 9.

Betwixt two numbers given to find a mean muſically proportional.

Multiply the difference of the termes by the leſſer terme, and adde

like-

likewiſe the ſame termes together; this done, if you divide that product by the ſum of the termes, and to the quotient, adde the leſſer terme, that laſt ſum is the muſical meane required: or ſhorter thus,

Multiply the termes one by another, and divide the product by their ſum, and the quotient doubled is the muſical meane required.

Example.

The numbers given being 6 and 12 multiplyed together, make 72, that divided by 18, the ſum of 6 and 12, the quotient is 4, which doubled is 8, the muſical mean required. This may be done by the line of numbers, otherwiſe thus, find the Arithmetical mean between 6 and 12, and then the analogy or agreement is thus,

As the Arithmetical mean found is to the greater terme, ſo is the leſſer terme to the muſical mean required.

PROB. 10.

Betwixt two numbers given to find a mean Geometrically proportional.

Divide the ſpace on the line of numbers, between the two extream numbers, into two equal parts; and the point will ſtay at the mean proportional required. So the extream numbers being 8 and 32, the middle point between them will be found to be 16.

PROB. 11.

Betwixt two numbers given to finde two meanes geometrically proportional.

Divide the ſpace between the two extream numbers into 3 equal parts, and the two middle points, dividing the ſpace, ſhall ſhew the two mean proportionals. As for example, let 8 and 27, be two extreams, the two meanes will be found to be 12, and 18, which are the two meanes ſought

PROB. 12.

To find the Square root of any number under 1000000.

The Square root of every unmber is alwayes the mean proportional betwen 1, and that number for which you would find a ſquare root, but yet with this general caution, if the figures of the number be even, that is 2, 4,6,8,10, &c. then you muſt look for the unit (or one) at the beginning of the line and the number in the ſecond part, and the root in the firſt part, or rather reckon 10 at the end to be the unit, and then both root and ſquare will fall backwards toward the middle in the ſecond length or part of the line: but if they be odd then the middle one will be moſt convenient to be counted the vnity, and both root and ſquare will be found from thence forwards toward 10. ſo that according to this

rule, the ſquare of 9, will be found to be 3, the ſquare of 64, will be found to be 8, the ſquare of 144, to be 12. the ſquare of 1444, to be 38. the ſquare of 57600, to be 240. the ſquare of 972196, will found to be 986. and ſo far any other number. Now to know of how many figures any root ought to conſiſt, put a prick under the firſt figure, the third, the fifth and the ſeventh, if there be ſo many; and look how many pricks, ſo many Figures there muſt be in the Root.

PROBL. 13.

To find the Cubique Root of a Number under

1 0 0 0 0 0 0 0 0 0.
1 1 1 1

The Cubique root is alwayes by the firſt of two mean proportionals between 1 and the Number given, and therefore to be found by dividing the ſpace between them into three equal parts;

parts : So by this means the root of 1728 will be found to be 12, the root of 17280 is neer 26, the root of 172800 is almoſt 56, although the point on the Rule repreſenting al the ſquare numbers is in one place, yet by altering the unit it produceth various points and numbers, for their reſpective proper roots. The Rule to find which is in this manner: You muſt ſet (or ſuppoſe pricks to be ſet) pricks under the firſt figure to the left hand, the fourth figure, the ſeventh and the tenth; now if by this means the laſt prick to the left hand ſhall fall on the laſt figure, as it doth in 1728, then the unit will be beſt placed at 1 in the middle of the Line, and the Root, the Square and Cube will all fall forward toward the end of the Line.

But if it fall on the laſt but 1, as it doth in 17280 then the unit may be placed at 1 in the beginning of the Line, and the Cube in the ſecond length, or elſe the unit may be placed at 10 in the end of the Line, and

the Cube in the first part of the Line, (but if the Cube fall out of the Line, you may help your self, as in the first Problem of the 2 Chapter.) But if the last prick fall under the last but two, as in 172800, it doth then place the unit alwayes at 10 in the end of the Line, then the Root, the Square, and Cube, will all fall backward, and be found in the second part, between the middle 1 and the end of the Line. By these Rules it doth appear that the Cube-root of 8 is 2, of 27 is 3, of 64 is 4, of 125 is 5. of 216 is 6, of 345 is 7, of 512 is 8, of 729 is 9, of 1000 is 10. As you may see by this following Table of Square and Cubique roots.

Thus you have the chief use of the line of numbers in general, and they that have skil in the rule of three and a little knowledge in plain triangles, may very aptly apply it to their particular purposes. Yet for their sakes for whom it is intended, I shall inlarge, to some more particular applications

cations in measuring all sorts of Superficies, and Solids; wherein I do judge it will be most serviceable to them that be unskilful in Arithmetick, as beforesaid.

A Table of Square and Cubique Roots.

Root. Sqn.	Cube.	Root. Square.	Cube.	Root.	Square.	Cube.
1	1	7	49	345	204	41616	8490000
2	4	8	64	512			
3	9	27	81	729	439	192721	84900000
4	16	64	9	1000			
5	25	125	10	1000	947	896809	849000000
6	36	216	12	1728			
			144	1728	1000	1000000	1000000000
			26	17280			
			676				
			56	3136	172800		

Chap. III.

The Use of the Line of Numbers in measuring any Superficial measure, as Board, Glass, and the like.

The ordinary measure, and most in use, is a *Twofoot Rule* divided into 24 Inches, and every Inch into 8 parts; that is, Halfs, Quarters, and Half-quarters; but these parts not agreeing with the parts on the Line of Numbers, which are Decimals, or tenth parts, is bred very much trouble; and there cannot be exactness without taking of smal parts, as $\frac{1}{2}$ quarters of Inches, or else using of Reduction; and it is also as troublesome by Arithmetick as by the Line of Numbers. To avoyd which, I would advise either to measure altogether by Foot-measure, (that is, a Foot divided into 1000 parts (or rather as is sufficient for ordinary use, 100) and then the divisions

divisions on the numbers will agree fitly to the parts on your Rule, without any trouble for Fractions; for so doing Fractions doe become whole Numbers as it were, and are wrought accordingly: But if you use it not in measuring, yet you may have it set for to help you for the ready reducing of such Numbers as shall require it, though I shall apply it to Inches also, as it is commonly used, that it may appear useful both wayes, accordingly as any man shall be affected.

The like reason holdeth for Inches, Yards, Ells and Perches, or any other measure; for thereby the Work is made more easie, as shall appear anon.

Therefore first by Foot-measure onely.

PROBLEM 1.

The breadth of an Oblong ſuperficies given in Foot-meaſure, to find how much in length makes a Foot.

Extend the Compaſſes from the breadth to 1, the ſame extent applyed the ſame way from 1, will reach to the length required.

So the breadth being 8 tenths, or 0 80, the length to make a Foot Superficial wil be found to be 1. 25. Or ſhorter thus, as 8 tenths (or 80 of a 100) is to 1, ſo is 1 to 1, 25 of an hundred.

PROBL. 2.

Having the length and breadth of any Superficies given in Foot-meaſure, to find the content of that Superficies in Foot-meaſure.

Extend the Compaſſes from 1 to the breadth, the ſame extent applyed the ſame way from the length, will reach to the Content.

Example.

Example.

As 1 is to 8, the breadth; so is 15 the length to 12, the content required; for a piece of 8 tenths broad, and 15 Foot long, containeth 12 Foot.

PROBL. 3.

Having the breadth and length of an Oblong Superficies given in Inches, to find the content in Inches.

As 1 Inch to the breadth in Inches. so the length in Inches to the Content in square Superficial Inches.

So the breadth 30 Inches, and the length 183, the Content will be found to be 5490.

Or else, as 1 to 183, so is 30 to 5490 Inches.

PROBL. 4.

Having the breadth and length of an Oblong superficies given in Inches, to find the Content in feet.

A 144 the number of Inches in one Foot

Foot, is to the breadth in Inches; so is the length in Inches unto the Content in Feet. So as 144 to 30, so is 183 to 38, 250, that is, to 38 Foot & a quarter.

PROBL. 5.

Having the breadth of an Oblong superficies given in Inches, and the length in Feet and parts, to find the Content in Feet, and such like parts as the length was.

As 12 to the breadth in Inches, so is the length in Feet to the Content in Feet.

As 12 unto 30, so is 15 to 37,50.

PROBL. 6.

Having the breadth in Inches, to find how much makes a Foot in Inch-measure, (that is, how many Inches makes a Foot.)

As the breadth in Inches to 144, so is 1 to the length in Inches. As 30 to 144, so is 1 to 48 Inches.

PORBL.

PROBL. 7.

Having the length and breadth of an Oblong ſuperficies, to find the ſide of a ſquare equal to it.

Divide the ſpace between the length and the breadth into two equal parts, and the middle point ſhall ſhew the ſide of the Square that ſhall be equal in *area*, or quantity, to that Oblong; ſo that a Square made of 11, 32, is equal to an Oblong of 16 one way, and 8 the other way.

PROBL. 8. *Of a Circle.*

Having the Diameter of a Circle, to find the ſide of a ſquare equal to that circle.

As 10000 to 8862, ſo is the Diameter 15 to the ſide of the Square 30, 29, that is equal to the Circle.

PROBL.

PROBL. 9.

Having the Circumference of a Circle, to find the side of a square equal to the same Circle.

As 10000 to 2821, so is the Circumference 47, 13 to the side of the Square 13, 29 equal to the Circle.

PROBL. 10.

Having the Diameter to find the Circumference.

As 1 is to the Diameter, so 3142 to the Circumference. Or, as 7 to 22, so is the Diameter to the Circumference.

So the Diameter being 15, the Circumference wil be about 47, 13 parts.

PROBL. 11.

Having the Circumference to find the Diameter.

As 3142 is to 1, so is the Circumference

ference to the Diameter: Or, as 22 is to 7, so is the Circumference to the Diameter.

So the Circumference being 47, 13. the Diameter is 15.

PROBL. 12.

To find the side of a square that may be inscribed within a Circle, by having the Diameter.

The extent from 1 to 7071 will reach from the circumference to the side of the Square required.

PROBL. 13.

By having the Circumference, to find the side of the inscribed square.

The extent from 1 to the Circumference, will reach from 2251 to the side of the Square required.

PROBL.

PROB. 14.

Having the Diameter to find the Superficiall content of a Circle.

The extent from 1 to the Diameter, being twice repeated (the same way) from 7854, will reach to the content required.

PROB. 15.

Having the Circumference to find the Superficial content of a Circle.

The extent from 1 to the Circumference, being twice repeated from 07958, will reach to the content.

PROBL. 16.

Having the content to find the Diameter.

The extent from 1 to 1 273, will reach from the content to another number, whose square root is the Diameter required.

PROBL. 17.

Having the content to find the Circumference.

The extent from 1 to 12,75, will reach from the content to another number, whose square root is the Circumference required.

PROBL. 18.

Having the content of a Circle to find the side of a square equall to it.

Extract the square root of the content by the 12 Probleme of the last Chapter, and that is the side required.

PROBL. 19.

To find the content of a Circle two wayes.

Multiply the Diameter by it self, and multiply that product by a 11, and divide this last product by 14 and the quotient shall be the content required.

Or

Or else.

Multiply half the Diameter and half the Circumference together, and the product is the content required.

PROBL. 20.

How to measure a Circle, a Semicircle, or a quarter of a Circle, or any part that goeth to the Center of the supposed Circle.

First for a Circle.

Take half the Diameter and half the Circumference, and measure it then as an oblong square; for the half circle take half the Diameter, and half the Semicircumference, and do likewise. Thirdly, for the quarter of a Circle, take half the arch of that quarter, and the Radius or Semidiameter of the whole Circle, and work as you would do with an oblong square peece, and you shall have your desire.

PROB.

PROBL. 21.

How to measure a Triangle.

Take half the base, and the whole perpendicular; and work with them two, as if it it were an oblong square figure, or you may take the whole base and half the perpendicular.

PROBL. 22.

How to measure a Rhombus, or a Rhomboides.

A Rhombus is a Diamond-like figure, as a quarre of glasse is containing 4 equal sides and two equal opposite angles; but a Rhomboides is a figure made of two equal oppofite sides and two equal oppofite angles: and to measure them you must take any one side, and the neareſt distance from that side to his oppofite side for the other side, and then reckon it as an oblong square.

PROB.

PROBL. 23.

How to measure a Trapezium.

A Trapezium is a figure comprehended of 4 unequal sides, and of 4 unequal angles: and before you can measure it, you must reduce it into two triangles, by drawing a line from any two opposite corners, then deal with it as two triangles, or you may save some work thus, the line you draw from corner to corner, will be the common base to both triangles: then say as 1 is to half the perpendiculars of both the triangles put together, so the whole base to the content.

PROBL. 24

How to measure a many sided irregular figure or Polygon.

You must reduce it to triangles, or to trapeziums, by drawing of lines from convenient opposite corners: and

and then the Work is all one with that of the laſt Problem.

PROBL. 25.

How to meaſure a many-ſided regular figure, commonly called a regular Polygon.

Meaſure all the ſides, and take the half of the ſum of them for one ſide of a Square, and the neereſt diſtance from the center of the Polygon to the middle of one of the ſides, for the other ſide of a Square; and with them two numbers work as if it were a Square Oblong figure, and it wil give the Content of the Polygon deſired.

PROBL. 26.

How to reduce Feet into Yards, Elns, or other parts.

Firſt for yards, if 9 foot make one yard, how many ſhall 36 foot mae. The extent from 9 to 2, will reach from 36 to 4, for ſo many Yards is

5 Foot.

36 foot. But if you were to measure any quantity by the Yard, as the Plaistering or Painting of a House, then I would advise you to have a yard to be divided into a hundred parts, (which is as neer as commonly workmen go to, or else, into a 1000 if you do require more exactnesse) and measure all your lengths and breadths with that, and set them down thus, 2 25 (or by 1000 thus 2 250) and the length thus 10 60, (or by 1000 again 10 600,) and multiply them together, and the product is the true content of that long square, the like holds for ells, or poles, furlongs, or any other kind of measure. Again, for a yard in length, if 3 foot make one yard, then what shall 30 make? it maketh 10, or the contrary if 10 yards make 30 foot, what shal 12 make? the extent from 10 to 12, will reach from 30 to 36 foot.

CHAP.

CHAP. IV.

The use of the line of Numbers in measuring of land by perches, and acres.

PROBL. 1.

Having the Breadth and length of an oblong Superficies given in perches, to find the content in perches.

As 1 perch to the bredth in perches, so the length in perches to the content in perches.

Example.

As 1 is to 30, so is 183 to 5490. (perches).

PROBL. 2.

Having the length and bredth in perches, to find the content in square acres.

As 160 to the bredth in perches, so is the length in perches to the content in acres.

As 160 unto 30, so is 183 to 34,31 (in acres and perches.)

PROBL.

PROBL. 3.

Having the length and bredth of an Oblong Superficies given in Chains, to find the Content in Acres.

It being troublesome to divide the Content in Perches by 160 we may measure the length and breadth by Chains, each Chain being 4 Perches in length, and divided into 100 links, then will the Work be more easie in Arithmetick, or by the Rule; for as 10 to the bredth in Chains, so the length in Chains to the content in Acres.

Example.

As 10 to 7.50, so is 45.75 to 34.31, (100 parts of an Acre.)

PROBL. 4.

Having the Base and Perpendicular of a Triangle given in Perches, to find the Content in Acres.

If the Perpendicular goe for the length,

length, and the whole baſe for the breadth, then you muſt take half of the oblong for the content of the triangle, by the ſecond problem, as 160 to 30, ſo is 183 to 34.31, or elſe without halving, ſay as 320 to the perpendicular, ſo is the baſe to the content in acres; as 320 unto 30, ſo is 183 to 17,15.

PROB. 5.

Having the perpendicular and baſe given in chains, to find the content in acres.

As 20 to the perpendicular, ſo is the baſe to the content in acres.

As 20 to 7,50, ſo is 45,75, to 17,15 parts.

PROBL. 6.

Having the content of a Superficies after one kind of perch, to find the content of the ſame Superficies according to another kind of perch.

As the length of the ſecond perch,

is to the first, so is the content in acres to a fourth number, and that 4th number to the content in acres required. Suppose a Superficies be measured with a chain of 66 feet, or with a perch of 16 ½ and it contain 34, 31 and it be demanded how many acres it would contain, if it were measured with a perch of 18 foot? these kind of proportions, are to be wrought by the backward rule of three, after a duplicated proportion: wherefore I extend the Compasses from 165. unto 18, 0, and the same extent doth reach backward, first from 34.31, to 31.45, and then from 31.45 to 28.84, the content, in those larger acres of 18 foot to a perch.

PROBL. 7.

Having the Plot of a field with the content in acres, to find the scale by which it was Plotted.

Suppose a plain contained 34 acres 31 Centesmes, if I should measure it with

with a ſcale of 10 in an inch, the length ſhould be 38 Chains and 12 Centeſmes, and the breadth 6 Chains and 25 Centeſmes, and the content according to that dimenſion, would by the 3 Problem of this Chapter be found to be 23,82. whereas it ſhould be 34.31, therefore to gain the truth, I divide the diſtance between 23.82 and 34, 31 into two equal parts, then ſetting one foot of the Compaſſes upon 10, the ſuppoſed true ſcale, I find the other to extend to 12, which is the length of the ſcale required.

PROBL. 8.

Having the length of the Oblong, to find the breadth of the acre.

As the length in perches to 160, ſo is one acre to the breadth in perches. As 40 to 160, ſo is 1 to 4. Again, as 50 to 160, ſo is 1 to 3. 20, ſo is 2 to 6 40; or again if you meaſure by chains, As the length in Chains to 10, ſo is 1 acre to his breadth in Chains; as 12

50 unto 10, so 1 to 0. 80, or if the length be measured by foot measure, then as the length in feet unto 43560 so is 1 acre to his breadth in foot measure.

So the length of the oblong being 792 feet, the breadth of one acre will be found to be 55 foot. the breadth of 2 acres 110 feet.

The use of this Table is to shew you how many Inches, Centesmes of a Chain, feet, yards, paces, perches, Chains, acres, there is in a mile, either long or square, or consequently any of them all, in any of the other that is lesse; as for example, I would know how many Inches there is in a long perch, I look on the uppermost row for Perches, and in the next row under, I find 198 for the quantity of Inches in a long Perch. But if I would know how many Inches there is in a square Perch, then look for perch on the left hand, and in the inch Colume you have 39204, for if you multiply 196 by 196, it will produce 39204.

A neceſſary Table for Menſuration of Superficial-meaſure.

	Inch.	*Centeſme.*	*Feet.*	*Yard.*	*Pace.*	*Perch.*	*Chain.*	*Acre.*	*Mile.*
Inch.	[1]	7 92	12	36	60	198	792	7920	63360
Centeſ.	62 7264	[1]	1. 515	4 545	7 575	25	100	1000	8000
Feet.	144	2 295	[1]	3	5	16 5	66	660	5280
Yards	1296	20 655	9	[1]	1 66	2 85	22	220	1760
Pace.	3600	57 485	25	8 335	[1]	3 3	13 2	132	1056
Perch	39204	625	272 25	90 75	10 89	[1]	4	40	320
Chain	627264	10000	4356	1452	17424	16	[1]	10	80
Acre.	6272640	100000	43560	14520	1742.4	160	10	[1]	8
Mile.	4014489600	64000000	27878400	9292800	1115136	102400	6400	640	[1]
Squar.	*Inches.*	*Centeſmes.*	*Feet.*	*Yards.*	*Pace.*	*Perch.*	*Chain.*	*Acre.*	*Mile.*

The like is for any other number in the whole Table, and is of very good use to reduce one number into another, or one sort of measure into another: as inches into feet, and feet into Yards, and Yards into Perches, and Perches to Chains, and Chains into Acres, & acres into miles, or the contrary either long-wise or square-wise: as is well known to them that have occasion for these measures. Thus much shall suffice for Superficial measure, the practice of which will make it plain to any ordinary capacity.

CHAP.

CHAP. V.

The use of the line of numbers in measuring of Solid measure such as Timber, stone or such like Solids.

PROBL. 1. By Foot-measure.

A peece of Timber being to be measured and not just square, how to make it square.

Divide the Space between the breadth, and the thickness, into two equal parts, and the Compasses shall stay at the side of the Square, equal to the oblong made of that breadth and thickness; which is the mean proportional between them. The breadth being 18, and thickneſse 6, the side of the Square will be found to be 10,38.

PROBL. 2.

Having the side of a square, equal to the base of any Solid given in Foot-mea-

ſure, to find how much makes a Foot Solid in Foot-meaſure.

As the ſide of the ſquare in Foot-meaſure unto 1, ſo is 1 to a 4th number, and that 4th to the length. As 2 120 unto 1.000, ſo 1.000 unto 0,471, and that to 0.222. or thus, the extent from 2. 120 to 1, will reach from 1, twice repeated to 0.222, and ſo much is the length to make a Foot Solid, (at that Squareneſſe.)

PROBL. 3.

To find how much in length makes a Foot, at any breadth and depth without ſquaring.

As 1 to the breadth in Foot-meaſure, ſo is the depth to a fourth number, as that 4th number to 1 ſo is 1 to the length in Foot-meaſure.

Example.

As 1 is to 2. 50, ſo is 1. 80, to 4. 50, then as 4. 50 to 1, ſo is 1 unto 0. 222. the length required.

PROBL.

PROBL. 4.

Having the ſide of Square, equal to the Baſe of a Solid given, and the length thereof in Foot-meaſure, to find the content in Feet.

As 1 to the ſide of the ſquare in Foot-meaſure, ſo the length in Feet to a fourth number, and that fourth to the content in Foot-meaſure. The extent from 1 to 2. 12, twice repeated from 15.25, ſhall reach unto 68.62.

PROBL. 5.

Having the length breadth and depth, of a Squared Solid given in Foot-meaſure, to find the content in Feet.

As 1 to the breadth in Foot-meaſure, ſo is the depth to the Baſe in Feet; as 1 to that Baſe, ſo the length in Feet to the content in Feet.

As 1 to 2, 50, ſo 1.80 to 4. 50, then as one 1 to 4. 50, ſo is 15. 25, unto 68. 625. The content required.

PROBL. 6.

By Inches, (onely) and Feet and Inches.

Having the ſide of a Square, equal to the baſe of any Solid given in Inches, to find how many Inches in length will make one Foot.

The ſide of the Square is found as in the firſt problem of this Chapter, or by the 7th of board meaſure. Then as the ſide of the ſquare, in Inches to 41,57, ſo is one Foot to a 4th number, and that 4th to the length in Inches, and tenth parts of an Inch.

The extent from 25,45 unto 41,57 twice repeated from 1 will reach to 2,67, or more eaſy if it be ſquared, as the ſide of the ſquare is to 12, ſo is 12 to a 4th and that fourth to the length required. The extent from 25,45 to 12 being twice repeated from 12, will ſtay at 2,667, or more ſhort 2 67.

PROBL.

PROBL. 7.

Having the breadth and depth of a squared Solid given in Inches, to find the length of a Foot in Feet and Inches.

As 1 to the breadth in Inches, so the depth to a fourth number, which is the content of the base in Inches, then as this 4 number is to 1728, so is 1 to the length of a Foot Solid in Inch measure. As 1 to 21,6, so is 30 to 648, then as 648 to 1728, so is 1 to 2,667.

Or again thus.

As 12 to the breadth in Inches, so the depth in Inches to a fourth number; then as this fourth number is to 144 so 1 to the length of a foot solid; as 12 to 21,6, so 30 to 54: then as 54 is to 144, so is 1 unto 2, 667. the length required.

PROBL.

PROBL. 8.

Having the side of the square and the length thereof given in Inch-measure, to find the content in Feet.

As 41. 57, to the side of the Square in Inches, so is the length to a fourth Number, and that fourth to the content in Foot-measure. As 41. 57, to 25. 45, so 183, twice repeated unto 68. 62.

PROBL. 9.

Having the side of a square equal to the Base of any Solid given in Inch-measure, and the length in Foot-measure to find the content in Feet.

As 12 to the side of the Square in Inches, so the length in Feet to a fourth Number, and that fourth to the content in Foot-measure. As 12 to 25. 45, so 15. 25 to 32. 55, and 32. 55 to 68. 62. Or the extent from 12 to 25. 45, twice repeated from 15. 25, shall reach to 68. 62, the content sought.

PROBL.

PROBL. 10.

Having the length, breadth and depth, of a Squared Solid given in Inches, to find the content in Inches.

As 1 to the breadth in Inches, so the depth to the base, then as 1 to the base, so the length to the content in Inches. As 1 to 21.6, so 30 to 648. as 1 to 684, so that 183 to 118584.

PROBL. 11.

Having the length, breadth and depth given in Inches, to find the content in Feet.

As 1 to the breadth in Inches, so the depth in Inches to the base in Inches; Then as 1728 to the base, so is the length in Inches to the content in Feet, As 1 to 21. 6, so 30 to 648, as 1728 to 648, so 183 to 68. 62,

Or you may say,

As 12 to 21.6, so 30 to 54, as 144 to 54, so 18 to 68. 62.

PROBL.

PROBL. 12.

Having the bredth and depth of a ſquared ſolid given in Inches, and the length in Feet, to find the content.

As 1 to the breadth in Inches, ſo the depth in Inches to a fourth number. Then as 144 to that fourth, ſo is the length in Feet to the content in Feet.

As 1 to 216, ſo is 30 to 648; then as 144 to 15. 25, ſo is 648 unto 68. 62, Or as 144 to 21. 6, ſo 30 to 4. 50: as 1 to 4. 50, ſo 15. 25 to 68. 62. Or again,

As 12 to 21. 6, ſo 30 to 54: then as 12 to 54, ſo 15. 25 to 68. 62, the content required.

CHAP.

CHAP. VI.

The Use of the Line of Numbers in measuring of Cylinders, by Foot-measure.

Problem 1.

Having the Diameter of a Cylinder given in Foot-measure, to find the length of a Foot solid in Foot-measure.

As the Diameter in Feet to 1.128, so is 1 to a fourth, and that fourth to the length in Foot-measure.

The Extent from (the Diameter) 1.25, to 1.128, being twice repeated from 1, will reach to 8.148, the length sought.

PROBL. 2.

Having the circumference given in Foot-measure, to find the length of a Foot-solid in Foot-measure.

As the Circumference in Foot-measure is 3.545, so is 1 to a fourth, and that fourth to the length sought.

As

As 3 *f.* 927 *p.* unto 3. 545, ſo is that diſtance twice repeated from 1 to 0, 818 the length of a Foot-ſolid.

PROBL. 3.

Having the Diameter and length of a Cylinder given in Foot-meaſure, to find the content in Foot-meaſure.

As 1.128 to the Diameter in Foot-meaſure, ſo is the length in Foot-meaſure to a fourth, and that fourth to the content in Foot-meaſure.

The Extent from 1. 128 to 1. 25, being twice repeated from 8. 75, will reach to 10. 737, the content ſought for.

PROBL. 4.

Having the Circumference and length of a Cylinder given in Foot-meaſure, to find the content in Foot-meaſure.

As 3. 545 to the Circumference in Feet, ſo is the length in Feet to a fourth, and the fourth to the content in Foot-meaſure.

The

The Extent from 3.545 to 3.927, being twice repeated from 8.75, will reach to 10.74, the content in Foot-measure.

PROBL. 5. *By Inch-measure.*

Having the Diameter of a Cylinder given in Inches, to find how many Inches makes a Foot solid.

As the Diameter to 46.90, so is 1 to a fourth number, and that fourth number to the length in Inches.

The Extent from 15 to 46.90, will reach from 1 (being twice repeated) to 9.778, the length sought.

PROBL. 6.

Having the Circumference given in Inches, to find the length of a Foot solid.

As the Circumference to 147.36, so is 1 to a fourth number, and so that fourth to the length in Inches.

The Extent from 47.13, to 147.36, being twice repeated from 1, will reach to 9.78, the length sought.

PROBL.

PROBL. 7.

Having the Diameter and length given in Inches, to find the content in Inches.

As 1 128 to the Diameter in Inches, ſo is the length to a fourth, and that fourth to the content in Inches. The extent from 1 128 to 15, being twice repeated from 105, will reach to 18555, 34 the content in Inches.

PROBL. 8.

Having the Circumferance and length, given in Inches, to find the content in Inches.

As 3, 545 to the Circumference in Inches, ſo is the length in Inches to a fourth number, and that fourth to the content in Inches. The extent from 3, 545 to 47, 13, being twice repeated from 105 will reach to 18555 the content in Inches.

PROBL.

PROBL. 9. By Feet and Inches.

Having the Diameter given in Inches and the length in Feet to find the content in Feet.

As 13,54 to the Diameter, so the length to a fourth number, and that 4th to the content in Feet. The extent from 13, 54 to 15, being twice repeated from 8, 75 wil reach to 10, 74, the content sought for.

PROBL. 10.

Having the Circumference given in Inches, and the length in Feet-measure to find the content in Feet.

As 42,54 to the Circumference in Inches, so is the length in Feet to a fourth, and that fourth to the content. The extent from 42, 54 to 47, 13; being twice repeated from 8,75, will reach to 10, 74 the content sought.

PROBL.

PROBL. 11.

It being an Ordinary way in measuring of round Timber such as Oake, Elme, Beech, Pear-tree, and the like, (which is sometimes very rugged, and uneven, and knotty) to take a line and girt about the middle of it, and then to take the fourth part of that, for the side of a Square equal to that Circumference: But this measure is not exact but more than it should be. But either because of allowance for the faults aboveſaid, or for Ignorance, the custome is still used, & men commonly think themselves wronged if they have not such measure. Therefore I have fitted you with a proportion for it both for Diameter, and Circumference.

And first for the Diameter.

The Diameter given in Inches and the length in Feet, to find the content.

As 1,526 to the Diameter, so is the length to a fourth, and that fourth to the

the content in Feet: according to the rate above ſaid.

The extent from 1. 526 to 9. 53, being twice repeated from 8, ſhall reach to 3. 12 the content.

PROBL. 12.

Having the Circumference in Inches, to find the content in the aboveſaid meſure.

As 48 to the Inches about, ſo is the length to a fourth number, and that fourth to the content. The extent from 48 to 30, being twice repeated from 8, ſhall fall upon 3. 12, the content required.

PROBL. 13.

How to meaſure Taper Timber, that is bigger at one end than at the other.

The uſuall way for doing of this, is to take the Circumference of the middle or mean bigneſs, but a more exact way, is to find the content of the baſe of both ends and add them together; and then to take the half for the mean, which multiplyed by the length, ſhall give you the true content. *Example.*

A round pillar is to be measured whose Diameter at one end is 20 Inches, at the other end it is 32 Inches Diameter, and in length 16 Foot (or 192 Inches) the content of the little end is 314. 286, the Area or content of the greater end is 773, 142, which put together make 1087, 428, whose half 543, 714. multiplyed by 192 the length, gives 104393, 143. Cubical Inches which reduced into Feet, is 60 Foot, and 713 cubical Inches, for the Solid content of the Pillar.

PROBL. 14.

To measure a Cone, such as is a Spire of a Steeple, or the like by having the heighth, and Diameter of the Base.

Example; let a Cone be to be measured, whose base is 10 Foot, and the height thereof 12 Foot, the content of the base will be found, by the 14 Problem of Superficial measure, to be 78,54; Then this 78,54 multiplyed by 4, a third part of 12, the perpendicular

pendicular or height of the Cone will give 314, 4, for the content of the Cone required, by the numbers work thus; the extent from 1 to 4, will reach from 78,54 to 314 4. But because there may be some trouble in getting the true perpendicular of a Cone, which is its height, take this rule; First, take half the Diameter, and multiply it in it self, which here is 25, then measure the side of the Cone 13, and multiply that by it self which here is 169, from which take the Square of half the base, which is 25 your first number found, and the remain is 144 the Square root of which, is the height of the Cone, or length of the perpendicular.

PROBL. 15.

To measure a Globe or Spheare arithmetically.

Cube the Diameter, then multiply that by 11, and divide by 21, gives you the true Solid content; let a Spheare

Spheare be to be measured, whose axis or Diam. is 14, that multiplyed by it self gives 196, and 196 again by 14 gives 2744, this multiplyed by 11 gives 30184, & this last divided by 21 gives 1437.67, for the content of the Spheare whose Diameter is 14. But more briefly by the Numbers thus, The extent from 1 to the Axis, being twice repeated from 3. 142, will reach to the Superficial content, that is, the Superficies round about. But if the same extent from 1 to the Axis be thrice repeated from 5238, it will reach to the Solid content; as 1 to 14, so 3. 142 to 617. being twice repeated, as 1 to 14, so 5278 to 1437. being thrice repeated. As for many sided figures if they have length, you have sufficient for them in the Chapter of Superficial measure, to find the base, and then the base multiplyed by the length giveth the content. But as for figures of roundish form, they coming very seldome in use, I shall not in this place trouble you with them,

them, for they may be reduced to Sphears or Cones, or Triangles, or Cubes, and then measured by those Problems accordingly. And so much for the mensuration of Solids.

Chap. VII.

Of Gaging of vessels.

The use of the line of numbers in Gaging of Vessels.

PROBL. 1.

The true content of a Solid measure, being known, to find the Gage-point of the same measure.

The Gage-point of a Solid measure is the Diameter of a Circle, whose Superficial content is equal to the Solid content of the same measure; so the Solid content of a wine Galon, (according to *Wincheſter* measure) being 231 Cube Inches, if you conceive

a Circle to contain ſo many Inches, you ſhall by the 16 Problem of board meaſure find the Diameter thereof to be 17. 15, for as 1 is to 1. 273, ſo is 231 to 294. 1, whoſe ſquare root by the 12 of the ſecond, is 17. 15, the Gage-point for Wine meaſure.

Thus likewiſe you may diſcover the Gage-point for Ale-meaſure, an Ale Gallon (as hath been of late diſcovered) containing 288 Cubique Inches. For as 1 is to 1. 273, ſo is 288 to 366. 7, whoſe ſquare root (by the 12 Problem of the ſecond Chapter) is 19. 15, the Gage-point of Ale meaſure, becauſe of ſoile and waſt exceeding that of wine juſt 2 Inches.

Another way by having the Diameter, length, and true content of any Veſſel.

Extend the Compaſſes on the line of numbers to half the diſtance between the content and length of the Veſſel, the ſame extent will reach from the Diameter to the Gage-point.

Example.

Example.

Here at *London* it is ſaid, that a wine Veſſel being 66 Inches in length, and 38 Inches in the Diameter, would contain 324 Gallons, if ſo we may divide the ſpace between 324, and 66, into two equal parts, the middle will fall about 146, and the ſame extent that reacheth from 324 to 146, will reach from the Diameter 38 unto 17. 15, the Gage-point, for a Galon of Wine or Oyle after *London* meaſure. The like reaſon holdeth for the like meaſure in all places. Now from what hath been ſaid doth neceſſarily follow this concluſion: that when the Diameter of a Cylinder in Inches, is equal to the Gage-point of any meaſure, given likewiſe in Inches: every Inch in the length thereof, containes one integer of the ſame meaſure. So in a Cylinder 17. 15, Inches Diameter, every Inch in the length thereof,

contains one intire wine Gallon, and in a Cylinder of 19. 15 Diameter, every Inch is one intire Ale Gallon.

PROBL. 2.

To find the equated Diameter two wayes, first by Arithmetique, as in Problem 8 *of the second Chapter.*

Add the two Diameters at head and bung together, (being measured in Inches) and the half sum keep. Secondly, Substract the Diameter of the head out of the Diameter at the bung, and note the remainder, which is to be divided by 4 or $4\frac{1}{2}$ (as by the numbers is easie) to find out a fourth (or somewhat lesse) part of the difference. Thirdly, that fourth part (or somewhat less) is to be added to the half sum kept, to make up the mean Diameter sought.

Example.

A Vessel hath in Diameter at the head

head 18 *in.* 3 *p.* & at the bung 21.5 Inches, I would know the mean Diameter 18. 3, and 21. 5 added, is 39. 8, the half is 19. 9, the lesse taken from the greater, the remainder is 0,3 2, which brought or reduced into 100 is 320. and in stead of dividing by 4 or 4 ½ say 45, & the product is 7 tenths and 3 over, which 7 tenths add to 19. 9, and it maketh 20. 6 tenths for the mean Diameter required to be found.

Another way by Geometry and somewhat more exact. Of the Diameter at the head, and bung, take the difference, then say as 1 is to 7, so is the difference to a fourth sum, which fourth sum is to be added, to the least of both the Diameters, *viz.* that at head, as in the former example 18. 30, and 21. 50 added is 39,80, whose half is 19. 90, and the difference is 0. 3.2, or 320, then say, as 1 is to 7, so is 320 to 2. 24, which 2, 24 if you take with your Compasses, out of your Scale of Inches, and add it to 18. 30, you shall see it reach to 20 Inches 54

parts, and this is the true mean Diameter, to make it a perfect Cylinder; or if you add 2 Inches 24 to 18.30, it makes it 20. 54 as before.

PROBL. 3.

Having the mean Diameter, and the length of a Vessel to find the content.

Extend the Compasses from the Gage-point to the mean Diameter, the same extent being twice repeated from the length, shall give the content in galons and 100 parts.

Example.

As 17. 15 to 20, so is 25 to 34, being twice repeated.

Again in a lesser Vessel.

As 17. 15 to 16, so is 23 to 20, being twice repeated from 23 the same way as from 17. 15 to 16.

PROBL.

PROBL. 4.

Having the Diameter and content, to find the length.

Extend the Compaſſes from the Diameter to the Gage-point, the ſame extent twice repeated from the content, ſhal give the length.

As 38. to 17. 15, ſo is 324 to about 66 twice repeated.

PROBL. 5.

Having the length and content, to find the Diameter of a Veſſel.

Extend the Compaſſes to half the diſtance, between the length and content, the ſame extent ſhall reach from the Gage-point to the Diameter.

Divide the ſpace between 66, and 324, in two equal parts, the ſame extent ſhall reach from 17. 15 to 38, the Diameter aboveſaid.

PROBL. 6.

Having measured a Vessel according to wine measure, to know what it holds in Ale measure, without knowing the Gage-point.

As 273 is to 231, so is the content in wine Gallons, to the content in Ale Gallons. Or the contrary, as 231 is to 273, so is the content in Ale Gallons, to the content in wine Gallons.

Example.

As 273. to 231, so is 116. 4, to 98. 76. and as 231 to 273: so is 98. 76, to 116.4, &c.

PROBL. 7.

To measure any vessel a more easy way.

There it yet a more easy way, and for exactness no way inferior to any extant, and that by taking the length in Inches and 10 parts, but the Diameters

meters at head and bung, with a line called Oughtreds Gage line, (and to be had at *John Brown's* house in *Dukes-Place*, Mathematical-Instrument-maker.) the use of which is thus, take the Diameter at the bung, with those divisions on the line aforesaid, from that end where the divisions begin to be numbred. And set that down twice: and the Diameter of the inside of the head (for so we understand all a long,) and set that down once. In this manner.

0'63 and then add them together, as
0'63 here you see, the length in Inches suppose to be (30. 82.)
051
177 Thirty and eighty two of a hundred: then say, As 1 is to 1. 77, so is 30. 82 to 54.55 hundred parts of a Gallon, being a little more than half a Gallon, which is 54 gallons $\frac{1}{2}$ the content of a high Countrey Hogshed, whose measures were as before.

One example more by this kind of Gageing. Suppose a great vessel whose length is 70. 50 Inches, and the Diameter at the bung 2 gallons 03 hundred parts, (for so they are properly called) and the Diameter at the head 1 gallon 10 parts, what is the content?

Set the two Diameters down, that at the bung twice, and that at the head once, and add them together thus. And then say as 1 to 5. 16, so is 70. 50, to 363. 78. the content sought for. That is 363 gallons 6 pints and a quarter, which 78 so to reduce do thus say on the line, As 100 to 80, so 78 to 6. 25, which is 6 pints and a quarter, the fraction sought.

D	2 03
	2 03
L	1 10
	5 16
70.50	

What is said here of Reduction is general in any other, as from 12 to 10, either shillings or Inches to tenths of a shilling, or tenths of a Foot,

Foot, or Pence or Farthings, Ounces, or Chauldrons, hundreds, either weight or Tale, and the rule is thus:

If 100 is 12 *d.* what shal 75 be? *facit* 9 Pence or 9 Inches.

If 100 be 112 *l.* what shal 50 be? *facit* 56 pound.

If 100 be 8 pints, what shall 25 be? *facit* 2 pints.

If 100 be 48 *f.* what shal 30 be? *facit* 14.4, that is, 3 *d.* 2 *f.* $\frac{1}{2}$ *neer.*

If 100 be 36 bushels, what shall 24 be? *facit* 8 Bushels $\frac{1}{2}$ and better.

If 100 be 60 min. what shall 50 be? *facit* 30 minutes, or half an hour.

If 100 be 120, what shall 80 be? *facit* 96, of 112 of nailes.

The like is for any kind of Reduction.

CHAP.

CHAP. VIII.

The use of the line of Numbers in Questions that concern Military Orders.

PROBL. 1.

Any Number of Souldiers being propounded, to order them into a Square Battle of Men.

Find by the 12 Problem of the second Chapter, the Square root of the number given; for so much as that root shall be, so many Souldiers ought you to place in Ranck, and so many likewise in File, to make a Square Battle of men.

Example.

Let it be required to order 625. Souldiers, into a Square Battle of men; the Square root of that number is 25; wherefore you are to place

25.

25 in Ranck, and as many in File, for fractions in this practice are not considerable. For had there been but but 3 less, there would have been but 24 in Ranck and File.

PROBL. 2.

Any Number of Souldiers being propounded, to order them into a double Battle of men: that is, which may have twice as many in Ranck as File.

Find out the Square root of half the number given, for that root is the number of men to be placed in file, & twice as many to be placed in ranck, to make up a double Battle of men.

Example.

Let 1368 Souldiers, be propounded to be put in that order: I find by the 12 aforesaid, that 26, *&c.* is the Square root of 684, (half the number propounded,) and therefore conclude, that 52 ought to be in ranck, and 26 in file, to order so many Souldiers into a double Battle of men.

PROB.

PROBL. 3.

Any number of Souldiers being propounded, to order them into a quadruple batail of men; that is four times so many in Ranck as File.

Here the Square root of the fourth part of the number propounded, will shew the number to be placed in File, and four times so many are to be placed in Ranck.

So 2048 being divided by 4, the quotient is 512, whose root is 22 (6) and so many are to be placed in File, & 88 in Ranck, being foure times 22, *&c.*

PROB. 4.

Any number of Souldiers being given, together with their distances in Ranck and File, to order them into a Square Battail of ground.

Extend the Compasses from the distance in File to the distance in Ranck; this done, that extent applyed the same way from the number of Souldiers propounded, will cause the movable point to fall upon a fourth number, whose Square root is the number of men to bee placed in File; by which, if you divide the whole number of Souldiers, the quotient will shew the number of men to be placed in Ranck.

Example.

2500 men are propounded to be ordered in a Square battail of ground, in such sort that their distance in File being seven Foot, and their distance in Ranck three Foot, the ground whereupon they stand may be a just square:

To

to resolve this question, extend the Compasses upon the line of numbers downward from 7 to 3, (then because the fourth number to be found, will in all liklyhood consist of 4 figures,) if you apply that extent the same way, from 2500, in the second part among the smallest divisions, the movable point will fall upon the fourth number you look for, whose Square root is the number of men to be placed in File. By which Square root if you divide the whole number of Souldiers, you have the number of men to be placed in Rank.

As 7 to 3, so 2500 to 1072, whose biggest square root is 32, then as 32 is to 1, so is 2500, to 78.

PROBL. 5.

Any number, of Souldiers being propounded, to order them in ranck and file, according to the reason of any two numbers given.

This Problem is like the former, for

for as the proportional number given for the file, is to that given for the ranck, so is the number of Souldiers to a fourth number, whose square root is the number of men to be placed in ranck, by which if you divide the whole, you may have the number to be placed in file.

Example.

So if 2500 Souldiers were to be martialled in such order, that the number of men to be placed in file, might bear such proportion to the number of men to be placed in ranck, as 5 bears to 12, I say then, as 5 is to 12, so is 2500 to 6000; whose Square root is 77, then as 77, is to 1, so is 2500 to 32, &c. The number of men to be placed in file.

CHAP.

CHAP. IX.

The use of the Line in Questions of Interest and Annuities.

PROBL. 1.

A sum of money put out to use, and the Interest forborn for a certain time, to know what it comes to at the end of that time, counting Interest upon Interest at any rate propounded.

Take the distance with your Compasses between 100, and the Increase of 100*l.* for one Year, (which you must do very exactly) and repeat it so many times from the principal as it is forborn years, and the point of the Compasses will stay on the Principal with the Interest, and increase according to the rate propounded.

Example.

I desire to know how much 125*l.* being forborne 6 year will be increased, according to the rate of 6*l.* *per cent.*

cent. reckoning Interest upon Interest, or Compound-Interest.

Extend the Compasses from 100 to 106; that extent being 6 times repeated from 125, shall reach to 177 *l.* the principal increased with the interest at the term of 6 years, at the rate propounded.

But if it were required for any number of Moneths, then first find what 100 is at one moneth, then say thus, If 100 give 10 *s.* at one moneth, what shall 125 be at six moneths end? *facit* 75 *s.* And the work is thus:

First say, If 100 give 10 *s.* at one moneths end, What shall 125? and it makes 12 *s.* 6 *d.* then say, If one moneth require 12 *s.* 6 *d.* What shall six moneths require? *facit* 75 *s.* that is, three pound fifteen shillings, the thing required to be found.

PROBL.

PROBL. 2.

A ſum of money being due at any time to come, to find what it is worth in ready money.

This queſtion is onely the inverſe of the other; for if you take the ſpace between 106 & 100, and turn it back from the ſum propoſed, as many times as there are years in the queſtion, it ſhall fall on the ſum required.

Example.

Take the diſtance between 106 and 100, and repeat it 6 times from 177, and it will at laſt fall on 125, the ſum ſought.

PROBL. 3.

A yearly Rent, Penſion, or Annuity being forborn for a certain term of years, to find what the Arrears come to at any rate propounded.

Firſt, you muſt find the principal that ſhall anſwer to that Annuity, then find to

to what ſum the Principal would be augmented at the rate and term of years propounded; then if you ſubſtract the Principal out of that ſum, the remainder is the Arrears required. *Example.*

A Rent, or Annuity, or Penſion of 10 pound the year, forborne for 15 years, What will the arrears thereof come to at the rate of *6 per cent.* compound intereſt?

The way firſt to find the principal that doth anſwer to 10 *l.* is thus: If 6 pouud hath 100 for his principal, What ſhall 10 have? *facit* 166 *l.* 16 *s.* or 166 *l.* 8 *s.* for the extent from 6 to 10 will reach from 100 to 166--8. which is 166 *l.* 16. Then by the firſt *Problem* of this Chapter, 166 *l.* 16 *s.* forborn 15 year, wil come to 398 *l.* then ſubſtract 166 *l.* 16 *s.* out of 298 pound, and the remainder, *viz.* 931 pound 4 ſhillings is the ſum of the arrears required. But note, in working this queſtion, your often turning, unleſs your firſt extent be moſt preciſely exact,

exact, you may commit a groſs error, to avoyd which, divide your number of turns into 2, 3, or 4 parts, and when you have turned over one part, as here 5, for three times 5 is 15, open the Compaſſes from thence to the principal, and then turn the other two turns, *viz.* 10--15. and this may avoyd much errour, or at the leaſt much mitigate it; for in theſe queſtions the larger the Line is, the better.

PROBL. 4.

A yearly Rent or Annuity being propounded, to find the worth in ready money.

Firſt, find by the laſt what the arrears come to at the term propounded, and then what thoſe arrears are worth in ready money, and that ſhall be the value of it in ready money.

Example.

What may a Leaſe of 10 *l. per ann.* having 15 year to come be worth in ready money? I find by the laſt *Problem*

blem that the arrears of 10 *l. per ann.* forborne 15 year, is worth 231 *l.* 14 *s.* And likewise I find by the second *Problem* that 231 *l.* 4 *s.* is worth in ready money 96 *l.* 16 *s.* and so much may a man give for a Lease of 10 *l. per ann.* for fifteen yeer to come, at the rate of 6 *l. per cent.*

But if it were not to begin presently, but to stay a certain term longer, then you must add that time to the time of forbearance; as suppose that after 5 years it were to begin, then you must say, 231 *l.* 4 *s.* forborne 20 years is worth in ready money, and it is 72 pound 8 shillings; and that shal be the value of the Lease required.

PROBL.

PROBL. 5.

A sum of money being propounded, to find what Annuity to continue any number of years, at any rate propounded, that sum of money will purchase.

Take any known annuity, and find the value of it in ready money; this being done, the proportion will be thus: As the value found out is to the annuity taken, so is the sum propounded to the annuity required.

Example.

What annuity to continue fifteen years will 800 *l.* purchase, after the rate of 6 *l. per cent.* Here first I take 10 *l. per ann.* for fifteeu yeer, and find it to be worth in ready money 96 *l.* 16 *s.* by the last *Problem*; then I say, as 96 *l.* 8 *s.* is to 10, so is 800 to 82-7, which is 82 *l.* 14 *s.* & so much neer do I conclude will an annuity of 82 *l.* 14 *s. per ann.* be worth for fifteen years, after the rate of 6 *l. per cent viz.* 800 *l.*

The

The application of the Line of Numbers to use in domestick affairs, as in Coals, Cheese, Butter, and the like.

I have added this Chapter, not for that I think it absolutely necessary, but onely because I would have the absolute applicableness of the Rule to any thing, be hinted at; for it may be the answer of some, Do you come with a Rule to measure my commodities which are sold by weight? Yea so far as there is proportion, it concernes that, and any thing else, the Application of which I leave to the industrious practitioner: onely I here give a hint. As much as to say, here is a treasure if you digg you may find, for some may be apt to think it being a Carpenters-Rule, it is fit but for Carpenters use only: but know, that in all measures which are either lengths, Superficials or Solids, or as some call them Longametry, Planametry, and Solidametry: and

in all liquids, by weight or measure, and in all time, either by Yeares, Moneths, Weeks, Dayes, Houres, Minuts, and Seconds, and almost (I think I may say,) in all things Number is used, and in many things proportional numbers, why then may not this line put in for a share of use, seeing it is wholly composed of, and fitted for proportional numbers, and of so easy an attainment, for any ordinary Capacity, and chiefly intended for them that be ignorant of Arithmetique, and have not time to learn that noble science as some have?

And first for more conveniency of Reduction, take these Rules of Reduction:

Rules for English Money.

Note that 4 Farthings, make a penny; 16 Farthings, 8 half pence, or 4 pence, make a groat, 48 Farthings, 24 half-pence, or 12 pence, make a shilling: 40 pence or 10 groats, is 3 shilling 4 pence; 80 pence,

20 groats, or 6 *ſh.* 8 pence, is a noble 160 Pence, 40 groats, or 13 *ſh.* 4. *d.* is a mark; 20 ſhillings, 4 Crownes, 3 Nobles, or 2 Angels, is a pound ſterling.

Rules for Troy-weight.

Note that 24 graines is a penny weight: 20 penny weights, or 24 Carrots, is an ounce Troy: 12 ounces is a pound: 25 *lib.* a quarter of a hundred, 50 *lib* half a hnuderd: 75 *lib.* 3 quarters of a hundred; & 100 *lib.* is an hundred weight Troy.

Rules for Aver-du-pois weight.

Note that 20 grains, make a Scruple: 3 Scruples, is a Dram: 8 Drams, is an Ounce: 16 Ounces, is a Pound, 8 Pound, a Stone: 28 *lib.* a quarter of an hundred; 56 *lib.* half an C. 84 *lib.* 3 quarters of an C. and 112 *lib.* or 14 Stone, or 4 quarters of a C, is an hundred weight: 5 C, is a Hogſhead weight: 19½ C, is a Fother of Lead: and 20 C, is a Tun weight,

and note that *l.* signifies a Pound in money: and *lib.* signifies a Pound in weight, either Troy, or Averdupois.

Rules for Concave Dry measure.

Note that 2 pints is a quart, 2 quarts a pottle, or a quarter of a peck: 8 pints 4 quarts, 2 pottles is one Gallon, or half a peck, 2 Gallons, is a peck: 2 pecks make halfe a Bushel: 4 pecks, or 56 *lib.* make a Bushel: 2 Bushels, is a Strike: 2 Strikes a Coomb, or half quarter; 2 Coombs 4 Striks, or 8 Bushels make a quarter, or a Seame: 10 quarters, or 80 Bushels make a Last.

Rules for Concave Wet-measure.

Note, that 2 pints is a quart: 2 quarts a pottle; 2 pottles 4 quarts, or 8 pints make a Gallon: 9 Gallons make a Firkin, or half a Kilderkin: 18 Gallons make 2 Firkins, a Kilderkin, or a Rundlet: 36 Gallons

lons is 2 Kilderkins, or a Barrel; 42 Gallons make a Terce, 63 Gallons or 3 ½ Rundlets make a Hogshead, 84 Gallons, or 2 Terces, make a Tercion, or Punchion: 126 Gallons, is 3 Terces, two Hogsheads, one Pipe, or But. A Tun is 252 Gallons 14 Rundlets, 7 Barrels, 6 Terces, 4 Hogsheads, 3 Punchions, 2 Pipes, or Buts. Note that in sweet Oyle 236 Gallons make a Tun, but of Whale Oyl 252 goes to the Tun.

Water Measure.

Note that 5 pecks is a Bushel, 3 Bushels a Sack, 4 ½ Bushels a Flat; 12 Sacks, 4 Flats, or 36 Bushels, make a Chaldron of Coales.

Rules for Long measure.

Note that 3 Barley cornes make an Inch: 2 ¼ Inches make a Naile: 4 Nailes or 9 Inches make a quarter of a Yard, 12 Inches make a Foot: 3 Foot, 4 quarters, 16 Nails, or 36 In-

ches, make a Yard. 45 Inches or 5 quarters of a Yard make an Ell, 5 Foot is a Pace, 6 Feet, or 2 Yards is a Fathom, 5 ½ Yards, or 16 ½ Feet, is a Pole, Rod, or Perch. 160 Perch in length, and one in breadth, or 80 Perch in length, and 2 in breadth, or 4 in breadth, and 40 in length, make an Acre.

220 Yards, or 40 pole, is a Furlong: 1760 Yards, 320 Poles, or 8 Furlongs, is an Englisth Mile; 3 Miles is a League, 20 Leagues or 60 miles is a Degree, in ordinary account, and every mile a Minute.

Rules for Motion, and Time, in Astronomy and Navigation.

Note that a Minute contain 60 Seconds, and 60 Minutes is one Degree: and 30 Degrees is one sign; 2 signes, or 60 Degrees is a Sextile ✱. 3 signes, or 90 Degr. is a quadrant, or quartile □: 4 signes, or 120 Degrees, a Trine △: 6 signes, or 180 Degr. is one oppositon ☍ or Semicircle:

circle, 12 Signs, or 360 Degr. is a Conjunction ☌ : and the Suns Annual, or Moons monethly motion. Note also, every hour of time hath in motion 15 Degrees. And a minute of time, hath 15 minuites of motion, and one Degree of motion, is 4 minutes of time.

Note further, that every hour of time, hath 60 minutes, therefore 45 is 3 quarters, 30 is half, 15 is a quarter of an hour; 24 houres a day natural; 7 dayes a week; 365 dayes and about 6 houres, is a yeare. Hence it followes, that $\frac{1}{4}$ of a Degree in the heavens, is 5 Leagues on the earth, or 15 minuts of motion above, is 1 minute of time below, therefore a Degree, or 60 minutes of motion, is 4 minutes of time as before is said.

All these rules, I shall expresse more largly, and in shorter termes, by these following Tables,

Equation for Motion.

	Signs.	*Degr.*	*Minutes.*	*Seconds*
Note that the 12 Signes is	12	360	21600	1296000
One Signe is	1	30	1800	108000
One Degr. is		1	60	3600
One Min. is			1	60

Equation for Time.

	Mon.	*Week.*	*Day.*	*Hour.*	*Minute.*
One *Year*	13	52	365	8760	525960
Month hath	1	4	28	671	40320
Week hath		1	7	168	10080
Day natural			1	24	1440
Hour hath				1	60
Minute is					

Equation for Long-measure.

	Mile.	*Furl.*	*Perch.*	*Yards.*	*Feet.*	*Inches.*
Leag	3.	24.	960	5971¼	15840	190080
Mile-	1--	8-	340-	1760-	5280--	63360
Furlong-	1--	40--	220--	--660---	7920	
Perch, Rod, Pole	1----	5½--	--16½-	——	198	
Acre contains of *Square Perch*	160-	880-	2640-	31608		
Acre is in { leng.	1---	40---	220---	660-	——	7020
Acre is in { bredth	—	4 ——	22-	—— 66-	——	792
1 *Rood*, or ¼ *of an acre is in* { len.	40-	——	——	——	——	——
	bred.	1---	5½----	16½-	---	198
One Fadom is	——	——	——	6	——	72
One Elne Engliſh is	——	——	——	3¾	——	45
One Yard is	——	——	——	3	——	36
One Foot is	——	——	——	1	——	12

One Inch is 1 *Inch* 3 *grains.*

Equation of Liquid-measure.

	Gallons.	Pottl.	Quart.	Pints.
Tun of sweet Oyl	236	472	944	1888
Tun of Wine is	252	504	1008	2016
Butt or Pipe is	126	252	504	1008
Tertian of wine is	84	168	336	672
Hogshead is	63	126	252	504
A Barrel of Beer, or 2 runlets of wi: is	36	72	144	288
Kilderkin or one Runlet is	18	36	72	144
Barrel of Ale is	32	64	128	256
Kilderkin of Ale	16	32	64	128
Firkin of Beer is	9	18	36	72
Firkin of Ale is	8	16	32	64

Equation

Equation of ſmall dry meaſure, and then of great meaſure.

	Peck.	Gal.	Pottl.	Qu.	Pi.
Buſhel of water-m. is	5	10	20	40	80
Buſhel of land-me. is	4	8	16	32	64
One Peck is		1	2	4	8-16
One Gallon is			1	2	4--8
One Pottle is				1	2--4
One Quart is					1--2

	Laſt.	Weig.	Chal.	Qu.	Buſh.	Peck.	Pints.
Laſt of Dry-m. is	1	2	2½	10	80	320	5120
One Weigh is		1	1¼	5	40	160	2560
Chaldron of coals		1	4	36	144	2098	
Quarter of wheat is			1	8	32	512	
One Buſhel is					1	4	64

Equation for Avoirdupois weight.

	Hogſheads.	C.	Stons.	Lib.	Ounces.	Drams.	Scruples.	Grains.
Tun W. groſs is	4	20	280	2240	35840	286720	860160	17203200
One Hogſhead is	1	5	70	560	8960	71680	215040	4300800
One C. or Hund. is		1	14	112	1792	14336	43008	860160
One Half C. is			7	56	876	7168	21504	430080
One Quarter of C. is			3½	28	448	3584	10752	215040
One Stone is				1	8	128	1024	3072	61440
One Lib. Pound is					1	16	128	384	7680
One Ounce is						1	8	24	480
One Dram is							1	3	9
One Scruple is								1	3

Equation for Troy-weight.

	Lib.	*Ounce.*	*Dp.*	*Carrots.*	*Grains.*
C. *wi*	100	1200	24000	28800.	576000
$\frac{1}{2}$ C *is*	50	600	12000	14400.	288000
$\frac{1}{4}$ C *is*	25	300	6000	7200	144000
$\frac{1}{8}$ C *is*	$12\frac{1}{2}$	150	3000	3600	72000
Pound	1	12	240	288	5760
Ounce		1	20	24	480
One Penny weight is		1	$1\frac{1}{5}$		24
One Carrot Troy is			1		20
One Grain is					1

Equation of Money.

	Mark.	*An.Nob.*	*Cro.Sh.*	*Groat.*	*Pence.*	*Far.*
Pound St.	$1\frac{1}{2}$	2	3	4	20	60	240	960
Mark is	1	$1\frac{1}{3}$	2	$2\frac{2}{3}$	$13\frac{1}{3}$	40	160	640
An Angel is	1	$1\frac{1}{2}$	2	10	30	120	480
A Noble is		1	$1\frac{1}{3}$	$6\frac{2}{3}$	20	80	320
A Crown is			1	5	15	60	240
A Shilling is				1	3	12	48
A Groat is					1	4	16
A Penny is						1	4

The use of which, (to come to our intended purpose,) may be thus. there you see how many farthings, pence, groats, shillings, and the like is in one, or any usual peece of coyne, also how many ounces, Scruples, in any kind of weight; and the like for measure, both Liquid and Dry; and also in time: now if you would know how many there shall be, in any greater number than one: then say by the Rule (or line of numbers) thus, If 48 Farthings, be one shilling, how many shillings is 144 Farthings, *facit* 3 shillings, for the extent from 48, to 1, will reach from 144, to 3. and the contrary. Again if a mark and a half be one pound, how many pound is 12 mark: the extent from 1-50, to 1. shall reach from 2, to 8. for reason must help you not to call it 80 pound: again if 3 Nobles be one pound, what is 312 Nobles? *facit* 104 pound. the extent from 3 to 1, will reach from 312 to 104.

Further,

Further, if a Chaldron of coales coſt 36 ſhillings, what ſhall ½ a Chaldron coſt? *facit* 18. (but more to the matter) if 36 Buſhel coſt 30 *ſh.* what ſhal 5 Buſhels coſt? *facit* 4.16. that is by reduction 4*s.* 2*d.* neer the matter, or penny, 3 Farthings, ½ Farthing, and better: or on the contrary; If one Buſhel coſt 8 pence, then what coſt 36? *facit* 288 pence; which being brought to ſhillings, is juſt 24. which you may do thus: If 12 pence be one ſhilling, how many ſhall 288 be? *facit* 24. for the extent from 12 to 1, ſhall reach the ſame way from 288 to 24. as before: the like may be applyed to to all the reſt of the rules of weight, and meaſure; of which take in fine, ſome examples in ſhort, and their anſwers.

If 14 Stone be one C, what is 91 Stone? *facit* 6 ½ C.

If one ounce be 8 Drams, how many Drams in 9 Ounces, *facit* 72, the Extent from 1 to 8 reacheth from 9 to 72.

If

If one Bushel of water measure be 5 Pecks, how many Pecks is 16 Bushels? *facit* 80 Pecks.

If one Barrel hold 283 pints, how much will a Firkin hold? this being the fourth part of a Barrel, work thus, if 1 give 288 what 25? *facit* 72, the answer sought.

If one week be 7 dayes, how many days is 39 weeks? as 1 is to 7, so is 39 to 273. So many dayes in 39 weeks.

If 160 perch be one acre, how many acre is 395 perch? *facit* 2.492, that is neer 2 ½ acres.

If 8 Furlongs make one mile, how much is 60 Furlong? *facit* 7 ½ mile: for the extent from 1 to 8, gives from 60 to 7.50.

CHAP.

CHAP. X.

To measure any Superficies, or Solid by Inches only, (or by Foot-measure) without the help of the line, by Multiplication of the two sides.

PROBL. 1.

Possibly that this little Book may meet with some that is wel skilled in Arithmetique, and being much use to that way, are loth to be weaned from that way, being so artificial and exact, yet though they can multiply, divide very well, yet perhaps they know not this way, to save their division and yet to take in all the fractions togethers as if of one denomination: I shall begin first with Foot-measure being the more easie, and I suppose my Two-Foot Rule to be divided into 200 parts and figured with 10. 20. 30. 40. 50. 60. 70. 80. 90. 100. And then so again to 200. as in

the 3 Chap. and then the work is onely thus: set down the measure of one side of the Square, or oblong thus, as for example, 7. 25, and 9. 88, and multiply them as if they were whole numbers, and from the product cut off 4 figures, and you have the content in Feet, and 10000 parts of a Foot, or Yard, Ell, Perch, or whatsoever else it be. Note the examples following.

7 25	12 29
9 88	19 72
58 00	24 58
580 0	860 3
6525	11061
71|6300	1229
	242|3588

For any kind of flat Superficies, this is Sufficient instruction to him that hath read the first part; but if it be Timber, or Stone, you must thus find the Base, and then another work will give you the other side, as in Chapter 5 problem 2.

PROBL.

PROBL. 2.

To multiply Feet, Inches, and 8 *parts of an Inch together without Reduction, and so to measure, Superficial (and Solid) measure.*

First, multiply all the whole Feet, then all the Feet and Inches, acroſs, and right on, then the parts by the Feet, and alſo the Inches, and parts, acroſs and right on then add them together, & you ſhal have the anſwer in feet, long Inches, (that is, in peeces of a Foot long, & an Inch broad) ſquare Inches, and 8 parts of a Square Inch, as for example,

Let a peece of Board be given to be meaſured that is 3. 3. 5. *i.e.* three Foot, three Inches, and 5 eights, one way, & 2.3.4, the other way. I ſet the numbers down in this Manner, & then right on, firſt as the line in the Scheme from 2 to 3 leads.

3.3.5.
2.3.4.

I ſay thus, 3 times 2 is 6, ſet 6 right under 2. and 43 as in the example, in the

the left page: for 6 Foot, as is cleer, if you consider the Scheme over the example, *viz.* the Squares noted with *f.* then for the next I say cross-wise, 2 times 3 is 6, *viz.* long Inches, as you may perceive, by the 2 long Squares, marked with 9L. and 6L. which 6, I put in the next place to the right hand, as in the example; then for the next, *viz.* 3 times 3. is 9, (Cross-wise, as the stroak from 3 to 3 shewes,) which 9 is also 9 long Inches, as the Scheme sheweth, and must be put under 6, in the second place toward the right hand, in the Scheme it is expresst, by the 3 long Squares, marked with L9. Then lastly for the Inches, 3 times 3 is 9, going right up, as the stroke from the 2 threes lead you, but note, this 9 must be set in the next place to the right hand, because they are but 9 Square Inches, but had the product been above 12, you must have substracted the 12s. out, and set them in the long Inches place, and the remainder

where

where this 9 now ſtandeth, and this 9 is expreſt in the Scheme, by the little Square in the corner markt with (□9.)

Then now for the Fractions, or 8 parts of an Inch, firſt ſay, croſwiſe as the longeſt prick line doth lead you to; 3 times 4 is 12, for which 12, you muſt ſet down 1. 6, that is 1 long Inch, and 6 Square Inches, the reaſon is, a peece 8 half quarters of an Inch broad, and 12 Inches long, is a long Inch, or the twelfth part of a Square Foot, and if 8 be 12 Square Inches, then 4 muſt needs be 6 Square Inches: therefore, in ſtead of 12, I ſee down 1. 6. as you may ſet in the example, and in the leaſt long Square of the Diagram, or Scheme. Then do likewiſe for the other long Square,

which

which is also multiplyed across; as, two times 5 is 10. that is, as I said before, 1. 3, as the Example and Scheme make manifest, considering what I last said, and it is marked by the 2. 00. But if this or the other had come to a greater number, you must have substracted 8 as oft as you could, and set down the remainder in the place of Square Inches, and the number of 8 in the place of Long Inches, as here you see.

Then for the two shorter Long Squares next the corner, say croswise again, Three times 5 is 15, that is 1. 7, because eight Half-quarters an Inch long do make one Square Inch, as well as eight Half-quarters a Foot long made one Long Inch: Therefore I set 1 in the place of Square-Inches, and 7 in the next place to the right hand, and it is expressed in the Diagram by the small Long-Square, and marked with * 1. 7.

Then again for the other little Long Square, say croswise, as the shorter

ſhorter prick line leads you, Three times 4 is 12, that is 1. 4; and do by this as the laſt: It is noted in the Scheme by 1--14.

Then laſtly for 5 times 4 as the ſhort prick line ſheweth you, is 20: out of which 20 take the 8 ſ. and ſet them down in the laſt place, and the 4 remaining you may either neglect, (or ſet it down a place further) for you cannot ſee it on the Rule, therefore, I thus adviſe, if it beunder 4 neglect it quite, but if above increaſe the next a figure more, if 4 then it is a half, and ſo may be added, for note, 64 of theſe parts make but one ſquare Inch; of which parts, the little Square in the right hand lower corner of the Scheme is 201, for wch I ſet down 2. 4, that is two Half-quarters, and 4 of 64. which is the laſt work, as you may ſee by the Scheme and Example.

Now to add them together ſay thus, 4 is 4, which I put furtheſt to the right hand, as it were uſeleſs, becauſe not to be expreſt; then 4 7 2 are 13,

from

from which take 8 and for it carry 1 on to the next place, or as many times 1 as you find 8, and set down the remainder, which here is 5, then 1 I carried, and 13619. is 21, from which I take 12, and set down 9, because 12 Square Inches, is one long Inch: then 1 I carried, (or more, had there been more 12 *s.*) and 1169 is 18, from which take 12, as before, there remains 6, that is, 6 long Inches, & so had there been more 12 *s.* so many you must carry to the next place, because 12 long Inches is one Foot, lastly 1 I carried, and 6 is 7 Foot, so that the work stands thus,

F. Lo. In--sq. In. 8----64

7—6—9—5—4

and so for any other measure Superficial or Solid.

CHAP.

An Appendix.

Chap. I.

The Description and use of a particular Sun-Dial made for the Latitude of 51. 30. North or the like for any other Latitude.

1 First, the Dyal it self is in form of a Quadrant, Sextance, or Circle, according as you please.

2. There is a string fitted, to hang the Horizontal line of the Dyal, Horizontally or parallel to the horizon.

3. There is the Center, hole, wherein to stick a pin straw, bent, or haire to give a shaddow.

Secondly, for the lines delineated on the Dyal, the first I shall take notice of is the Horizontal line, and it is a long streight line drawn per-

 pendicular

pendicular to the ſtring, and cuts the Center juſt in the middeſt.

2. You have next the Verge or Limb, (be it quadrant, Sextance, or Circle) the 90 Degrees of a quadrant, or but 60 of 90, if it be but a Sextance, or of a round form, being ſufficient for this Latitude: and the figures on that line is 10.20.30.40.50.60. 70.80. 90.

3. Next to that (toward the Center, and concentrick or paralell to the former Circle of degrees) you have a line of quadrat, or ſhadows or if it be larg you may have both quadrat, & ſhadows, and the figures, on the quadrat are, 10.20.30.40.50. & then back again to 1.10 or in larg quadrants the 50, is called a 100 and 10.20, and 20. 40. *&c.*

But the line of ſhadows, is figured with 12.11.10.9.8.7.6.5.4.3.2.1. in the middle againſt 50, and then 1. 2.3. to 12. back again; the firſt part of which is called the right ſhaddow: the other is called contrary ſhadows.

4.

4. Next to that you have two more lines, (concentrick to the former in quadrants & Sextances; But in round dyalls, they are but as it were concentrickal) on which are divided a Kalender of moneths & dayes, if they be large, but in those of ordinary bigness, is but every fifthand tenth day expressed: & single days are reasonably understood, of which two Circles the uppermost containes that half year in which the days be increasing, *viz.* from the 10. of December to the 10. or 11. of June; and the lowermost Circle containes the other half, decreasing or shortning. And at the end of every moneth there is a long stroke, being the last day of that moneth, and then by that, in the next moneth, you have the first letter (or more letters,) of the name of that moneth, so that all the letters in these two lines are: I. F. M. A. M. I. I. A. S. O. N. D for January, February, *&c.*

5. Next to the Kalender, you have

25 concentrick Circles, if they are lines of declination, or but 19 if they be lines of the Suns rising, and every 5 of them if they be declinations, or every fourth if they be lines of rising, is expreſt and diſtinguiſhed with pricks; for every 5 and tenth Degree of declination, or for every whole, and half hour of Suns riſing; as the figures ſet to them, at the end of them (next the Horizontal line) ſhew, if they be of Suns riſing being 4.5. 6. or the contrary end if they be lines of delination, noted with 10.20. will ſhew; the uppermoſt of which 25, or 19 lines, repreſents the *Æquinoctial*: and the loweſt the two *Tropiques* of *Cancer*, and *Capricorn*.

6. Thoſe lines which deſcend downwards ſloping from the *Æquinoctial* (or uppermoſt concentrick Circle,) to the *Tropique* (or lowermoſt Circular line,) towards the right hand are the Summer houre lines; and are 9 in number, when they are only whole houres. But in large

large Dyals there may be put halfs, & quarters, and then there are 8 prickt hour lines, for 12 being the laſt needs no pricks for diſtinction. And they are figured above the *Æquinoctial* with 6.7.8.9.10.11.12, and under the *Tropiques* with 8.7.6.5.4.3.2.1.12. for the ſame line hath two figures *viz.* 4 & 4, 7 & 5, 6 & 6, 5 & 7, 4 & 8, 3 & 9, 2 & 10, 1 & 11, 12 & 12. That is, the ſame line that is for 4 in the morning, is for 8 at night, and the like is both for winter and ſummer, the reaſon is, look how high the Sun is at 7 in the morning, ſo high is it at 5 in the after-noon, and the like.

7. Thoſe lines that deſcend from the *Æquinoctial* toward the left hand are the winter houres, and are figured above as before, but below with 12. 1. 2. 3, for in the ſhort dayes, the Sun ſets before 4, and in larg Dyals, there are halfs, and quarters alſo, and diſtinguiſhed as before, but of whole houres at the *Tropiques* there is but 4, but at the *Æquinoctial* there be 6,

and a point repreſenting the hour of 6.

8. And laſtly, in the ſpace roome beyond the *Æquinoctial*, you have ſet a perpetual Almanack, whereby, if you know the day of the moneth, you may find the day of the week, and the contrary.

Alſo in ſome Almanacks, you have the Dominical letter, Leap-year, and Epact, to find the Moons age, the largeſt and uppermoſt of which rancks of figures, are the 12 moneths, the next 5 are the 31 days of the moneth, and the reſt, if any be, are according to their names: thus much for deſcription.

One thing more I think convenient to hint, to make it ſerve for all faſhions of Dyals of this kind, and it is this; ſome Dyals of this kind, have the Kalender of moneths and dayes on the back-ſide, in 1, 2, or 4 Circles and lines of the Suns declination, riſing, true place, and amplitude and the right aſcenſion; and the

the use is only thus. Lay a thred on the day of the moneth and the Center, and it cuts or sheweth all the other in their respective lines. It being so easie & also not to our present purpose, I shall not give any example, but come to the uses of the foreside, which are sufficient for the hour of the day, the thing promised.

Chap. II.

The use of the Dyal.

PROBL. 1.

How to hold the Dyal in time of Observation.

Hang the string of the Dyal over your thumb, on your left hand, (or you may hold it between your thumb, and the middle of your fore finger) and stretch your 4 fingers streight out, and let the Dial hang at liberty, just touching the palm of your hand, that

it may be ſteady, then turn your whole body about, till the edge of the Dyal (or your fingers ends) be juſt againſt the Sun: then ſhall you ſee the ſhadow of any thing ſtuck in the Center, though never ſo ſhort, to reach quite through the Dyal, and then it is held right.

PROB. 2. *To find the Suns Altitude.* Stick a pin (the ſmaller the better) in the Center, and hold it up as before, and the ſhadow will ſhew on the limb the Suns Altitude required.

Exam. At 8 of the clock on the 11 of *June* in the morning, I would know the Suns Altitude; I hold it up as before, and I find it to be 36. 46, that is 36 Degrees and 46 minutes, each Degree being 60 minutes as in the Tables of reduction. *PROBL.* 3. *To find the perpendicular height of any thing by its ſhadow, by the line of ſhadows.*

Hold up the Dyal by the thred as before, and look on what diviſion of the line ſhadows, the ſhadow of the pins cuts, that is the true height or

length

length of the ſhadow, by which to get the height of any perpendicular thing, or the very top of any leaning thing, that cauſeth the ſhadow.

Ex. On the ſame 11 of *June*, at neer 9 a Clock in the morning, I hold up my Dyal, and I find the ſhadow to fall juſt on 1, on the line of ſhadows, or 45 on the Degrees, therefore I ſay, that the height of the object, that cauſeth the ſhadow, and the ſhadow are both of one length: but if it had fallen on 2, (that is to ſay, of right ſhadow) then the object is, but half the length of the ſhadow meaſuring upon a level ground, from the end of the ſhadow, to right under the object that cauſeth the ſhadow; if it falls on 3, the ſhadow is 3 times as long as the thing is, and ſo to 12, to 12 times longer, and the ſtrokes between note one tenth, 2 tenths, 3 tenths, &c. more, but if it falls beyond 1, on contrary ſhadow, then the ſhadow is ſhorter accordingly, as will appear very plain with a little practice.

PROBL. 4.

The use of the Quadrat.

To use the Quadrat, you must have a hole in the other end of the horizontal line, and also some where in the Dyal, square (from the Center) to the horizontal line; also you must have a thred and plummet, then the use is thus; Stick a pinn in the Center, and thereon hang the plummet, then put a pin in the other hole, that is perpendicular to the horizontal line, and just over the Center; and hold up the Dial in your right hand, and make the string to play evenly by the Superficies of the Dyal, when you see the object right against both the pins; then observe what stroke is cut by the thred on the line of quadrat, (or shaddows for that may be used so also,) for if you go backwards or forwards till you make the thred to fall on 1, in the shadowes, or on 50 in the quadrat then is the height of the house, Steeple, or Tree or the like,

equal

equal to the distance, between you and it, adding the height of your eye to it. But if it had fallen on 25 of the quadrat, or 2 on the shadows, then the distance had been twice as much as the height, (if right shadow) but for contrary shadow, the contrary. I shall say no more to this, only give you a caution, that if you look from the height of any place downwards, then you must put that pin next the Center to your eye, and looke downwards to your object, and then the side which before was right shadow, will become contrary shadow, and the contrary. Note one thing further, that if your instrument be a Sextance, or a Circle, and you cannot have all the quadrat, as on a quadrant: you may then move the pin to the hole at the other end, of the horizontal line: and you shall see that defect to be supplyed. Note lastly, that by heights, we speak only of perpendicular or upright heights; and in distances, only of levels, or horizontals.

FROBL.

PROBL. 6.

How to find unacceſſable heights by the quadrate at two Obſervations.

If the place which is to be meaſured cannot be approached unto, then work thus, to find both height and diſtance, firſt make choice of a place where looking up I find the thred to on 50 in the quadrat, then the diſtance will be equal to the height. Then make a mark at that Station, and go directly backward in a right line, with the former diſtance: and make choice of a ſecond Station, where the thred may fall on 25 parts of right ſhadow, then this ſecond Station is double to the height, and alſo to the diſtance, departed from the firſt Station: and the half therefore is the height, and firſt diſtance. But if it be ſo you cannot come to take ſuch a height as 50 and 25, then take as you may, as ſuppoſe one be at 25, and the other at 20, and ſuppoſe the height to be 100, I find that, As 25 the parts cut, are to 50 the ſide of the quadrat,

quadrat, ſo is 100 the ſuppoſed height, unto 200 the diſtance. And as 20 the ſecond Station, to 50 the ſide of the quadrat; ſo is 100 the ſuppoſed height, unto 250 the ſecond diſtance; wherefore the difference between the Stations ſhould ſeem to be 50, then if in meaſuring you find it to be either more or leſſe, then this proportion doth hold as from the ſuppoſed difference, to the meaſured difference, ſo from the ſuppoſed height, to the true height, & from the ſuppoſed diſtance, to the true ſuppoſed diſtance.

And now ſuppoſe the difference between the two Stations were found to be 30, by meaſuring, Then as 50 the ſuppoſed difference, to 30 the true difference, ſo is 100 the ſuppoſed height, to 60 the true height; And 200 the ſuppoſed diſtance, to 120 the true; and 250 at the ſecond Station, unto 150 the diſtance; the like reaſon holdeth, in all other examples of this kind, and if an index with ſights were fitted to the Center, it might ſerve for all other horizontal diſtances by the ſame reaſon. *PROBL.*

The Use of the Almanack.

PROBL. 7.

Having the Day of the Week, to find the Day of the Moneth for ever.

First find what day of the Week the first of *January* is on; which is thus done: First find the Dominical Letter for the last Leap-year, set down in the Almanack: the next letter is for the next year following and so til you come to the year you look for: And note every Leap-year hath two Dominical Letters, *viz.* the next before it, till the 24 of *February*, and that over it for the remainder of the year: Having found it, reckon from (*A*) either backwards or forwards, (alwayes calling (*A*) Sunday) you shall find what day is the first of *January*.

Example.

For the year 1656 (*F*) is the Dominical

minical letter; therefore say (*A*) Sunday, (*G*) Monday, (*F*) Tuesday, and that is the first of *January*; and then make use of that thus: On the first Tuesday in the beginning of *Februar.* I would know the day of the Moneth? Among the Moneths look for 12, which is for *February*, reckoning from *March*, (which is always the first Moneth) and right under 12 you have 5, for the fifth day, being the first Tuesday in *February*, and 12, 19, 26 for the other Tuesdayes in *February*: But now for the other Months after *March*, you must say Wednesday, the reason is, because *February* hath 29 dayes, and the Leap-year two Dominical Letters, *viz. F* & *E*; then reckon from *E* to *A*, and it falls on Wednesday, which use thus in the year 1656, and all other Leap-years: As, in the beginning of *August* on Thursday, what day of the moneth is it? *August* is the sixth Moneth, look for 6 among the Moneths, and right under it you have 6, which is Wednesday,

neſday, therefore 7 is Thurſday, and the firſt Thurſday in *Auguſt*. But now for 1657. I find that Thurſday is the firſt of *January*; ſaying thus, (*A*) Sunday, (*B*) Saturday, (*C*) Friday, (*D*) Thurſday: And ſo it is all the year long, in all the Moneths; for having found the moneth, all the dayes right under are Thurſdayes, and then reckon onwards, or backwards for any other of the Week-dayes, and you have your deſire, for any year paſt, preſent, or to come.

PROBL. 8.

To find the Epact, and by that the Moons age any day of the Moneth.

On the Leap-year you have it ſet down in the Almanack for the next year; add 11. and you have your deſire. And for the next year add 11 to that, & ſo to the next lep-year: But if by ſo adding it exceed 30, then take way 30, and the remain is the Epact.

Having

Having the Epact, adde to it the day of the Moneth, and the number of the Moneth from *March* also, (including both the Moneths) & if they come not to 30, that is the Moons age; but if they exceed 30, and the Moneth have 31 dayes, then substract 30, and the remain is the age; but if the Moneth have but 30 dayes, then substract but 29, and the remainder is the age of the Moon required.

Example.

In *July*, 1656. on the 20 day the Epact is 14. then 14. 20 & 5 added, is 39. from which take 30, rest 9 dayes old on the 20 of *July*, 1656. the Moons age sought for.

PROBL.

PROBL. 9.
To find the hour of the day.

Having found the day of the month by the Almanack, you must find the mark, or the space between two marks in the Kalender, representing that day; which do thus:

Look for the first letter, or name of the moneth in the Kalender, according to the time of the year, then reckon from thence to the day you are in, either by 5, 10, 15, 20, 25, 30, 31, if the parts are so divided, as in small Instruments they cannot well be more; but if you have single days, every fifth and tenth is known from the rest by a longer stroke, and the last day by the longest stroke: Well, having found the day, or the place between two strokes representing it, lay a thred from the center over that day, (or for want of a thred, stick a pin in the center, and cause the shadow to fall upon the day) and then observe

obſerve on which, or between which of the 25 or 19 lines the thred cuts the 12 of clock line, for on that line muſt you look for the hour all that day: Before I come to example, I ſhall hint a plain word of the reaſon of this, which I find ſome to marvel at; The hour of the day in this, and in moſt Inſtrumental-Dials, is given by the Suns height; now all men know the Sun is not ſo high in Winter as in Summer, therefore the Summer hour lines will not ſerve the Winter; and alſo all men know they lengthen by degrees gradually, therefore the Winter and Summer 12, and conſequently the reſt of the hour lines run ſloping upwards and downwards, as the dayes lengthen or ſhorten. This being premiſed and conſidered, an eaſier Dial (all things conſidered) cannot be had. Now for an Example or two:

Having found out the parallel of Declination, (for ſo is it called) if there be 25 lines, (or of the Suns riſing

sing, if there be but 19) you may easily know it by the name at the end of it, or by being a prick line, or the next to, or the 2 next to a prick line, *&c.* hang or hold the Dial up, as was taught in the Problem, and you shall have the exact hour of the day, among the Summer or Winter hours, according to the time of the year. *Example.* On the 2 ● of *Aug.* 1656. I look for (*A*) in the lower end of the moneths, because the dayes shorten, and laying a string (or causing a shadow to fall) from the center upon the 2 of *August*, which (if it hath not a particular stroke for it) is a little beyond the long stroke by the (*A*) and toward the (*S*), and I observe the thred to cut upon the line of Declination, called 15, and also it is a prick line, (in one of 25 lines (but almost midway between the first, beyond a prick line) & may be called the line of the Suns rising, at 4. & 41 min.) then I hold up my Dial, and find at 8 a clock the shadow to cross the 8 of clock line; just

just in the prick line, & at the same instant, the Suns altitude is 30. 15, and the quadrat is 29, and the line of shadows is 1. & 7 tenths, (that is the shadow of a yard (or any thing) held upright, is the length of the yard, and 7 tenths more of another length or yard) and note, that at 4 a clock the same day the shadow will fall in the same place exactly, as was hinted before; for equal hours from 12. the Sun hath the like altitude at all times of the year; and if it is morning, the height increases; if afternoon, then it decreaseth, and two observations will resolve the question.

First, for the moneths of *June* and *Decem.* where the days are close together, the reason is, because the days at that time lengthen or shorten but a little; so must their spaces be on the instrument; if you should miss 3 or 4. days there, it makes no sensible error, take as neer as you can, & it sufficeth. Also note the hours of 11 & 12 are neer together, therefore you must be so much the more cautious in observing

ving to hold the Dial well, and to look just on, or between the parallel of declination or rising, and at 12 of the clock you may look in the Kalender for the day of the moneth, for just on that day will the shadow be at 12 of the clock, and short of it (increasing) before, (but decreasing) after 12.

Note also on the 10 of *March*, and 13 of *September*, you must observe in the upper line; but on the 11 of *June*, & 11 of *December* on the lowest line, as the rules rehearsed make manifest.

Lastly, if you meet with a Dial that hath the Kalender of Months on the backside, then it is but laying a thred over the day, and on the line of Declination, the thred cuts the correspondent number of Declination, as before; also the rising, and true place, and amplitude, as I hinted before: Then having the number, look for the line on the other side that shall have the same number, and proceed as before. Thus much shall suffice for the Dial particular for one latitude.

CHAP.

Chap. III.

The description of a Universal Dial, for all Latitudes, from 0 to 66. 30. of North or South Latitude.

1 First the Dyal it self is an oblong, made of Box, Brasse, or Silver, or the like, and at the shortest side it hath two sights, either of it self, or fitted into it: parallel to one of the shortest sides.

2 It hath a Bracheolum (with a thred, bead, and plummet fastened to it:) that is 3 peeces of Brass so fitted together, that being pin'd on the middle, will reach to any of the lines of Latitude, and it may be cut away after the work is on, to a very comely Form, or left Square, as shall best please the Fancy.

3 Thirdly for the lines, on the Dial, consider first the center on the 6

of

of Clock line, where the tangents of Latitude begin, and paſs on to 66.30, being ſtraight parallel lines, drawn croſs the oblong to every ſingle Degree of Latitude: and you have them numbered with 10.20.30.40.50.60. 65: at both ends of thoſe lines.

4. Then you have from the Center aforeſaid, long ſtreight ſloping lines, drawn to every 5 or 10 Degr. of the ſignes, & on that end next the ſights, on the middle line, you have ♈ and ♎, from thence toward the left hand, you have 10. 20. ♉ and ♍: and then onwards the ſame way ſtill, 10. 20. ♊ and ♌: then 10. 20 ♋. on the other ſide, to the right hand you have 10. 20. ♐ and ♑: and 10. 20. ♒ & ♓: and 10. 20. ♈. In all 12 ſignes.

5. Alſo adjoined to them, you have a Kalendar of moneths and dayes, that knowing the day of the moneth, you have the ſign anſwering thereto.

6. You have the ſame Signes as was above pourtrayed on the right ſide, and

and 5 and 10 parts reciprocal to the former signes and parts on the top.

7. You have the hour lines, parallel to the length of the oblong, and numbred with 12.1.2.3.4.5.6.7.8.9.10.11.12. on the upper end of them: and with 12.11.10.9.8.7.6.5.4.3.2.1.12. at the lower end.

8. About the 2 sides opposite to the right upper corner, you have Degrees of Altitude, and Declination To find the Latitude, the use of which followeth, with as much brevity, and plainness as may be.

PROB. 1.

To find the Latitude.

Having the Suns Declination, and his Meridian Altitude, to find the Latitude.

When the Sun is just on the Meridian, observe his Altitude, and set it down: then find his Declination for that day, and consider whether it be North or South, for if it be North Declination, you must substract it from it; if South you must adde it to

the Meridian Altitude found, and the Sum, or remainder, shall be the complement of the Latitude sought for.

Example.

I am on the first of *August*, in a place where the Noon Altitude is 50, the Suns Declination the same day is 15. 18. North, which taken out of 50, there remains 34. 42, whose complement to 90 is 55. 18. the Latitude sought.

The Degrees have the signs added to them, so that when you have the Suns place by the help of the Kalendar above, look for the like Suns place in the Degrees, and just against it, you have his Declination: and when you have the Latitude by this, or any other meanes, you may find the hour of the day in this manner.

PROBL 2.

To find the Hour of the day.

Having the day of the Moneth, by the help of the Almanack as before; Find the same day in the Kalendar of Moneths and dayes, and right against it,

it, you have the Suns place in the *Zodiack*, or 12 signs: then bring the end of the *Bracheolum* to the same sign, or part of the sign, in your respective Latitude, and bring the Bead on the string, to the same sign and Degree, among the signs on the right side, then is it rectified for Observation; then hold it up, till you see the Sunbeams pierce through both holes of the sights, the thred playing easily by the side, the same time the Bead will fall upon the houre of the day, if it be the fore-noon reckon among the fore-noon hours, but if it be after-noon, among the after-noon houres, for the same as was 9 in the morning, is 3 in the after-noon & so of the rest.

On the 10 of *April*, in the Latitude of 51. 30, at 8 a Clock, I would find the hour of the day by this Instrument. First, I look for the tenth of *April*, in the Kalendar, and right against it I find ♉, that is, the Sun is then entring ♉, then I come down in that line, till I come to the Latitude

of 51. 30: and there I set the hole, in the end of the *Bracheolum*, where the thred is fastened; then that being fixed there, I bring the Bead on the string, to the same sign ♉, on the right hand; and then it is rectified for that day and Latitude: then hold it up as before, and you shall find the Bead, to fall on the line called 4 & 8, that is 8 in the morning, and 4 in the after-noon. As before said.

PROBL. 3.

To find the time, of the Suns rising, or Setting.

Rectifie the instrument as before, and make the string lie parallel to the hour-lines and the bead will shew you the time of the Suns rising, reckoning in the Morning hours, and his setting, reckoning in the after-noon hours; and by them you may have the length of the day and night; for if you reckon backward to 12 at night, you have the length of the night; the other way gives you the length of the day, being doubled.

Example.

Example.

On the 10 of *April*, the Index or Bracheolum rectified, and the Bead set right, and the string drawn straight and parallel to the houres, the Bead falls on 5 for the Suns rising, and 7 for his setting: then from 7 to 12 at night is 5 hours, which doubled is 10 hours, the length of the night; and from 5 to 12 at noon, is 7, which doubled is 14 hours, the length of the day.

CHAP. IV.

The Description and Use of the NOCTURNAL.

There are two plates in the Nocturnal, or more commonly it is one plate of brass on the backside of another Instrument; for the one hath onely 24 hours, and each houre is divided into quarters, or more parts, as the largeness of the plate will admit. This Nocturnal hath the houre divided into 12 parts, that is, into 5 minutes a peece, and when the Nocturnal is added

added to another instrument, these hours and parts are set on that, and this is one part of it.

The other part of it is a Rundle, or round plate of Brass, on which is described, first and next the Edge, 365 divisions, representing the dayes of the year, every moneth having the name, at the beginning of it, or the first letter of the name, *viz.* I. F. M. A. M. I. I. A. S. O.N. D. and a longer stroke, at the last day, than any of the rest; and figures at the tenth, and twentieth day, for the more ready finding of it: next within you have the 360 Degrees of a Circle, to find the right ascension of any star, and numbered with 10.20.30.40.50. to 360. beginning at the tenth of *March*, and proceeding onwards as aforesaid.

3. Then you have a Scale of Declinations, numbred both wayes, from the Equator, and Pole, *viz.* 10. and 80, 20. & 70, 30. & 60, 40. & 50. 50. & 40, by which you may find the Declination, or distance from the pole of any star.

4. You have 5 Conſtellations of thoſe Stars next the North Pole, and the reſt of the Stars of other conſtellations, as come within that compaſs. The names of which conſtellations are, the great Beare, the little Beare, Cephus, Caſſiopeia and the Dragon, and part of Perſeus, and Auriga.

5. You have a ſtring lying croſſe the Diameter, from 12 to 12, for a Meridian. The uſes follow in order.

But for their ſakes that may be willing to know more Stars, than are here ſet down, I have provided a larger plate, all the noted Stars, from the North Pole to the *Æquinoctial*, whoſe uſe is the ſame with this, therefore I ſhall ſpeak no more as to the uſe of that than this: only there is more variety, and it is a great help to the knowing of the Stars, for which cauſe it was by me chiefly compoſed.

Firſt then for the uſe, the moſt hard and difficult thing is to know the Stars one from another: The beſt means to know which, next to a Tu-

tor, is to compare them you do know in the Rundle with them in the heavens, and then one with another, as thus:

In a night when the Stars may be seen, and it is best for to learn when there is not so many Stars seen, (as there is in some cleer frosty nights) for then onely those in the Nocturnal will be seen: Look toward the North part of the heavens, and you shall see 7 fair Stars standing as you see the 7 in the great Bear, beginning at the tail of the Bear; & the two last being bright Stars; from which two, if you conceive a line to be drawn, it will cut the Pole-star; and when you find the Pole-star, and them two, they will help you to find all the rest with diligent observation.

Another way to find the North-star, is to hang a plummet on the Center, and make it play on the degree of the latitude of the place, and then lift it up toward the North part of the heavens, till you see a bright

star,

ſtar, ſo bright, as one of the 7 in the great Bear, for that is the Polſtar. *Note* that it is not the very Pole, as you may ſee by the *Nocturnal*, but it is the neareſt the Pole; this being known, and the great Bear, which almoſt every Countrey-man knows, by the name of *Charls-wane*; with help of the ſtring lying acroſs, you may ſtraightway look Eaſt or Weſt, North or South, or between, for any of the Stars ſet down in the Nocturnal, for the ſtring you muſt conceive to lye North and South alwayes: By theſe or the like means you may come to know all the Stars in the Nocturnal. And if you attain to know them, with the help of the other paper, you may know al in the half-Hemiſphere, that is between the Pole & Equinoctial.

Secondly, to find when any ſtar comes to the Meridian. The Meridian is a line or arch of a Circle, conceived to be drawn through (or rather by the ſtar in the tail of the little Bear, which is) the Pole Star, right over

over your head; and to make you understand this the better, Hang a line with a weight at the end of it, out of a window that looks to the North, a good way from the house, or on a tree, or corner of a house, and then go to & fro till you see the line cut by the North-star, how much & on which side the Nocturnal will shew you, & that line then is the meridian-line; & then what star soever is under the line & the North-star, or Pole, (for when you use the stars of *Cassiopeia*, the star is the true Pole, as by the Meridian-line on the Nocturnal you may plainly see) that star I say is exactly on the Meridian, be it above or below the Pole; for so it be in that direct line with the Pole, it matters not, so you have the houres divided round about; but you may be able in a little practice to guess, without the Plumb-line, yet it will marvellously rectifie your judgment, till you be more ready at it. These two being known, all the rest is very easie as may be.

3. The

3. The day of the Moneth being given, and a Star on the Meridian, to find the hour of the night.

Suppose on the 1 of *August*, I see by the means beforesaid, the Star in the tip of the great Bears tail, to be in the meridian, then bring that Star, just under the string, and look for the 1 of *August*, and right against it, you have 4 a Clock, and 8 minutes in the morning. *Another example.*

Suppose on the same night, the star in the nose of the Beare, were in the meridian, then bring that Star under the string, & the 1 of *Aug.* will shew 10. 37, that is 37 minutes past 10 at night: the like is for any other.

4. To find the right ascension of a Star, bring the Star under the thred, and the thred sheweth his right ascension in the degrees, so you will find the right ascension of the Star in the great Bears taile to be 203.

5. To find the declination of a Star, bring the Star under the line, then prick a pin through the string, and just

juſt in the middeſt of the Star, then keep the pin there; and bring the Scale of declination, right under the line, and pin: and the pins point ſheweth you his declination, or diſtance from the Pole; by theſe two laſt, you may add any Star, whoſe right aſcenſion, and declination you know; and ſo put in all, as may be ſeen in this compaſſe, at any time or by the right aſcenſion only (being ſufficient for this purpoſe, to wit the hour of the night,) you may add the Buls eye, little Dog, 7 Stars, Orion, or any other chief principal fixed ſtar: & make uſe of it, to find the hour of the night withal. 6. the day of the month, and hour being given, to know what ſtar is on or neer the meridian. Set the day of the moneth to the hour of the night, and the ſtars that are under the ſtring, are all on the meridian: and if there be none juſt, you ſhall ſee what half, or 3, or 4 part, beween 2 is on the meridian, and this is an excellent way, to help you to know the ſtars.

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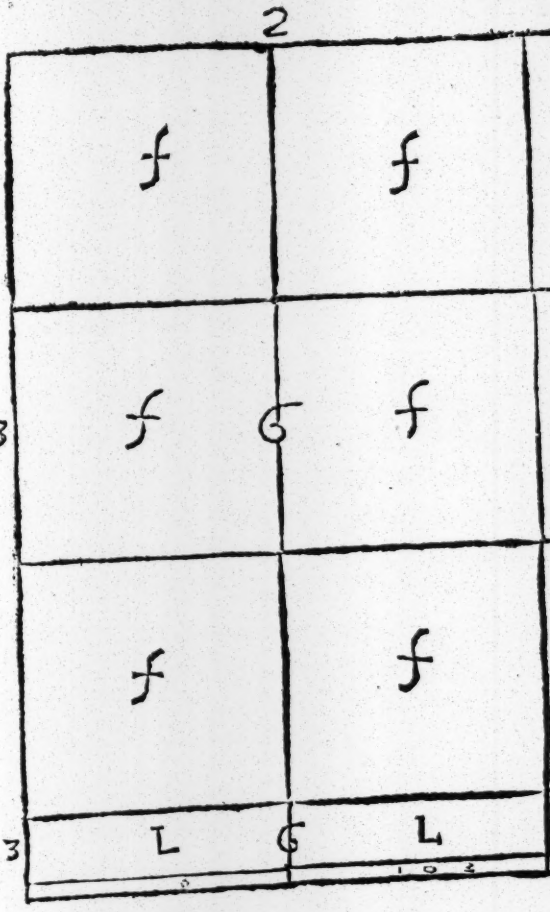

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